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September 1993

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US Army Corps
of Engineers
Waterways Experiment
Station

Evaluation of Methods for Controlling Dust

by Richard H. Grau
Geotechnical Laboratory

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Prepared for Headquarters, U.S. Army Corps of Engineers

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Waterways Experiment Station
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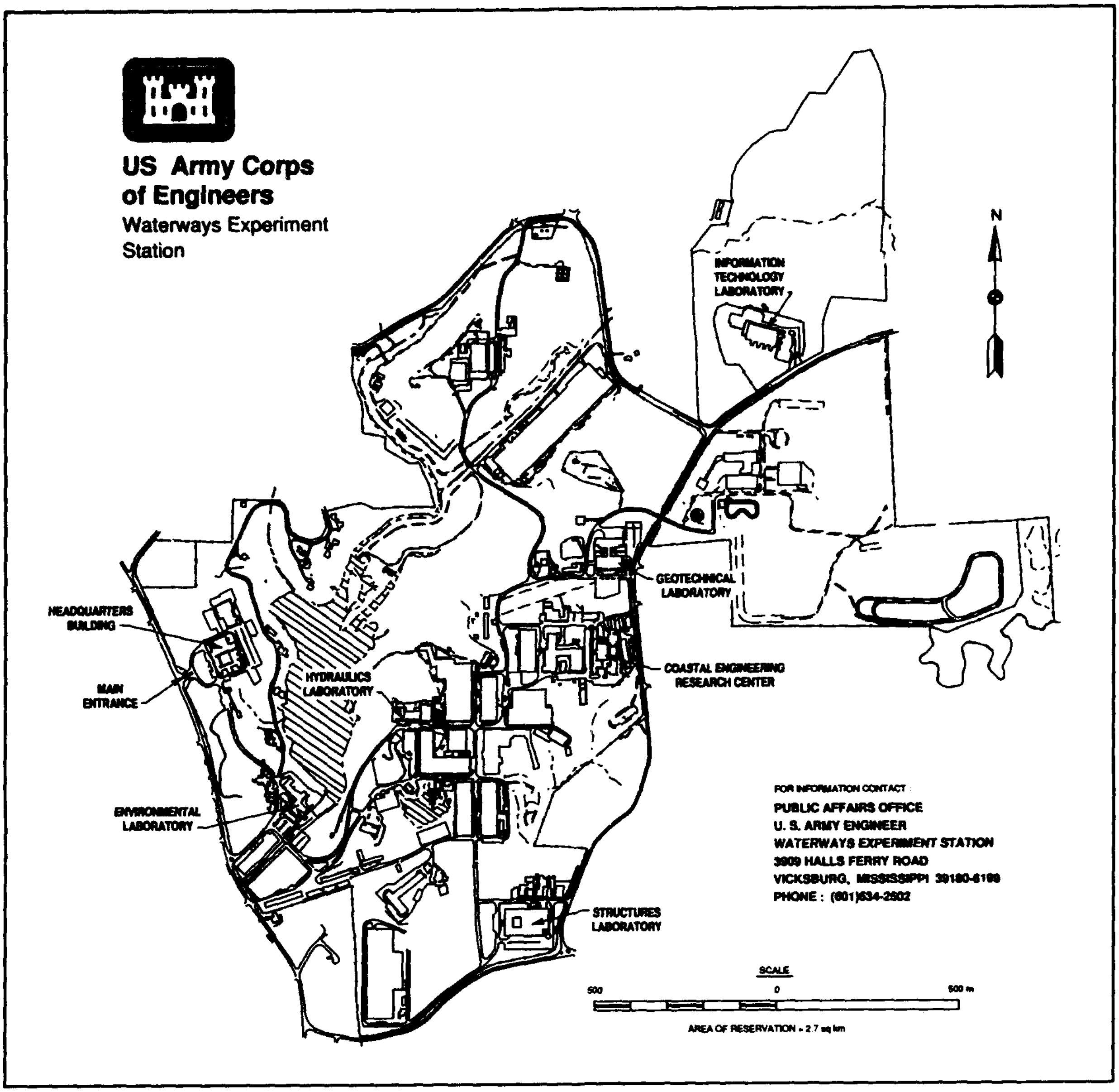

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Contents

Preface

The investigation reported herein was sponsored by the U.S. Army Corps of Engineers (USACE) and was conducted under Project AT40, Task RC, Work Unit 007, "Rapid Methods for Dust Control." The Technical Monitor was Mr. Gregory Hughes, USACE.

The study was conducted at the U.S. Army Engineer Waterways Experiment Station (WES) from October 1990 through September 1993 by the Pavement Systems Division (PSD), Geotechnical Laboratory (GL). Personnel of the PSD involved in this study were Messrs. R. H. Grau, C. J. Smith, T. P. Williams, and A. M. Payton. This report was prepared by Mr. Grau.

Field evaluation of selected dust control products were conducted at Yuma Proving Ground, AZ (YPG) during December 1991 through September 1992. Mr. Tony Bereznuk, Combat Branch, Combat Systems Engineering, YPG was our point of contact.

The study was conducted under the general supervision of Dr. W. F. Marcuson III, Director, GL, and under the direct supervision of Drs. G. M. Hammitt II, Chief, PSD, and A. J. Bush III, Chief, Criteria Development and Applications Branch, PSD.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]
feet	0.3048	meters
gallons (U.S. liquid)	3.785412	cubic decimeters
gallons per square yard	4.5273	cubic decimeters per square meter
inches	2.54	centimeters
miles (U.S. statute)	1.609347	kilometers
pounds (force)	4.448222	newtons
pounds (force) per square inch	6.894757	kilopascals
square feet	0.09290304	square meters
square inches	6.4516	square centimeters
tons (2,000 pounds, mass)	907.1847	kilograms

[1] To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the formula: $C = (5/9)(F - 32)$. To obtain kelvin (K) reading, use: $K = (5/9)(F - 32) + 273.15$.

1 Introduction

Problem

Controlling dust on military operational areas involve unique challenges. The Army must be provided effective, efficient means of suppressing dust on airfields, helipads, cantonment areas, roads, and tank trails where the presence of dust is detrimental to military operations. When helicopters operate in dusty environments, their rotary blades and engines must be replaced after only one-third to one-half of their normal life due to the erosion of surfaces caused by airborne soil particles. Dust clouds around military installations provide the enemy with easily recognizable signatures of strategic operations and impair visibility of both airborne and ground personnel. In addition, safety and health hazards, as well as low morale result from continuous exposure of personnel to extreme dust conditions.

Dust control materials used in mission areas must be capable of being applied to operational areas by Army engineer troops, indigenous personnel under engineer supervision, or by contract personnel responsible for area maintenance.

History

Since 1946, research by the Corps of Engineers on dust control materials had been conducted as a companion activity to a more comprehensive military soil stabilization program. The primary consideration was given to materials that, when blended with soils to a relatively shallow depth and then compacted, would provide a dust free and waterproof soil layer.

The emphasis of the dust control program shifted in late 1964 towards materials that could be applied to soil surfaces by spraying rather than admixing. Subsequent field tests of three proprietary materials, a petroleum resin emulsion, a concrete curing compound, and a special cutback asphalt (Peneprime), were conducted in conjunction with landing mat and membrane studies at various military installations. Of the three materials tested, the special cutback asphalt was found to be the most effective and was

recommended for use in the Southeast Asia (SEA) theater of operations until a more effective material could be developed.

In January 1966, WES was requested by the U.S. Army Corps of Engineers (CE), to undertake a program for de ·eloping dust control materials for use at military bases but primarily for use in SEA.

The U.S. Army Engineer Waterways Experiment Station (WES) began the dust control program by placing emphasis on the elimination of dust at peripheral (nontraffic) areas of expedient airfields and heliports. Guidelines were established for performance requirements and physical characteristics of a dust control material, and these guidelines were used as the basis for the Department of the Army Approved Qualitative Material Requirement (QMR) for Dust Control Material, dated 1 August 1966 (revised 10 May 1971).

During a conference at WES on 24 January 1966, 45 representatives of 25 industries were informed of the directive from CE and were requested to submit research proposals for new dust control materials as well as information on products already available. Subsequently, contracts were negotiated with various research organizations, and the testing phase of the program was begun.

The initial phase of testing consisted of laboratory tests in which controlled weather conditions were used to determine the suitability of a material for use in a tropical environment. Upon successful completion of the laboratory tests, a material was scheduled for traffic and downwash blast tests. Once a material passed all phases of testing at WES and was considered to show promise as an effective dust control agent, production quantities were procured for field testing at several military installations.

A total of 315 materials were received during the course of the investigation. Forty-nine of the materials processed through the laboratory screening tests were examined further, and 18 were selected for testing in the field. These tests involved the better asphalt products, a natural rubber latex, and several emulsions, one of which was DCA-1295.

DCA-1295, a polyvinyl acetate (PVA) contract-developed material, was selected as having the greatest potential for meeting the requirements for a military dust control material. Engineer tests/expanded service tests of DCA-1295 and fiberglass scrim were initiated in 1972 by the U.S. Army Armor and Engineer Board and the U.S. Army Test and Evaluation Command to determine if these materials would satisfy requirements contained in the QMR for dust control material. The tests were completed in 1974 and DCA-1295 and the fiberglass scrim were placed in the Army Supply System.

Purpose

The purpose of this investigation was to develop and/or identify and evaluate new materials that have become available since the SEA related effort of the late 1960's and early 1970's that will provide the Department of Defense with effective means of suppressing dust in mission areas. The goal was to develop new materials that would effectively control dust while reducing equipment, manpower, and logistical requirements by 30 percent as stated in the Army Science and Technology Master Plan, STO: V.J.3. Lines of Communication (LOC)-Construction Materials and Methods.

Scope

Dust control materials were applied to prepared soil specimens and tested under controlled laboratory conditions to determine their performance when subjected to simulated field conditions. Selected materials were applied to field test sections and evaluated to determine their performance when trafficked by military vehicles.

2 Laboratory Study

Two separate laboratory studies were conducted. The initial study was conducted to evaluate materials that would be effective in a desert climate and the second study was conducted approximately one year later to evaluate materials that would control dust in tropic and temperate climates. During both studies, the performances of the dust control materials were compared to the performance of CSS-1, an emulsified asphalt, that had been used successfully during Desert Shield/Desert Storm.

Private industry was notified of WES' interest in dust control products by two advertisements published in the Commerce Business Daily. The first advertisement was published in November 1990; it was concerned with controlling dust in desert climates. The second advertisement was published in December 1992; it was concerned with controlling dust in tropic and temperate climates. Both advertisements stated that the products must be effective in suppressing dust on airfields, helipads, cantonment areas, roads, or tank trails where the presence of dust is detrimental to military operations.

Materials Tested

Thirty-two products were evaluated during this investigation. These products included latexes, emulsions, acids, lignosulfonates, polyurethanes, chlorides, and molasses. Table 1 lists each material and its assigned laboratory number, the name and address of the supplier, the supplier's designation, and a general description of the product. When the products were submitted, the supplier included the mission area(s) where they would be effective and directions for applying them. The mission areas included nontrafficked areas where all traffic (including foot traffic) could be controlled, helicopter landing pads, wheeled-vehicle roadways, and tracked-vehicle roadways. Most of the products listed in the table were assigned a numeric/alpha laboratory number. This indicates that the supplier recommended more than one use for the product, or more than one application rate was recommended. The first 24 products were evaluated for use in desert climates. The products identified with underlined laboratory numbers were evaluated for use in tropic and temperate climates.

Laboratory Tests

Laboratory tests were conducted on all of the dust control products in order to quickly and economically eliminate the need for large scale field testing of all of the products. Flow diagrams that show details of the testing procedures for the products recommended for use in a desert climate and those recommended for use in temperate and tropic climates are shown in Figures 1 and 2, respectively.

Four different soils were used during these tests. A gradation curve for each of the soils is shown on Figures 3 through 6. The Yuma sand was used when the materials were evaluated for use in a desert climate, and the other three soils were used when the materials were evaluated for use in tropic and temperate climates. Each of the soils was air dried and then processed in an oven to reduce the water content to simulate dry soils that would cause dusty conditions. The water contents of the processed soils were as follows: Yuma sand (SP)- 2 to 3 percent, silt (ML)- 4 to 6 percent, clayey silt (ML)- 6 to 8 percent, and gravelly clayey sand (SC)- 5 to 6 percent. Soil samples were prepared by placing soil into plastic molds, lightly compacting the soil, and screeding the top smooth. The average densities of the soils were as follows: Yuma sand (SP)- 99 lb/cu ft[1], silt (ML)- 88 lb/cu ft, clayey silt (ML)- 90 lb/cu ft, and gravelly clayey sand (SC)- 107 lb/cu ft. The plastic molds used to contain the soil samples were 6 in. square by 3 in. deep. A set of three soil samples ready for application of a test material is shown in Photograph 1.

In most cases, the material suppliers requested the surface of the dry soil be prewet prior to application of their product. This prewetting would break existing surface tension and allow the dust control material to penetrate into the soil sample. Prewetting of the dry soil samples was accomplished by spraying a fine mist of water (usually at a rate of 0.05 to 0.10 gal/sq yd) onto the surface of the sample.

The dilution and application rate for each product was specified by the manufacturer or supplier. The dilution rates ranged from applying the product as received to mixing one part of the product to 400 parts of water. The application rates ranged from 0.09 to 4.00 gal/sq yd; however, the majority of the application rates ranged between 0.30 and 0.50 gal/sq yd. The dust control products were applied with a specially designed laboratory spray device, Photograph 2. The device was designed so three molds could be sprayed as the nozzle moved across the soil samples. The spray device was adjusted before each product was applied so the desired application rate could be achieved. Adjustment was accomplished by changing the spray nozzle, pressure, dilution ratio, and nozzle traverse speed. Since the density of each product was known, the exact coverage rate was determined by weighing the soil sample before and after treatment.

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[1] A table of factors for converting U.S. customary units of measurement to metric units is presented on page v.

After treatment, the samples were cured in the laboratory under sun lamps for a period of four hours, see Photograph 3. The temperature on the surface of the samples varied from 100 to 120°F depending on whether the product was being evaluated for use in tropic and temperate climates or desert climates.

At the end of the cure period, the treated samples were subjected to one minute blasts of 50 and 100 mph winds directed to impinge the treated surface at an angle from the horizontal of 20 degrees. A compressor was used to generate pressures of 7 and 30 psf, respectively, required to produce the airblasts through a 3/8- by 5-in. aperture. The test apparatus (Photograph 4) simulated the airblast of a C-130 aircraft and UH-1 helicopter. Failures of the dust control materials during this test were easily recognized. The film forming materials peeled lose from the soil surface when they did not develop an adequate bond with the soil, and portions of the crust formed by penetrants blew away when the soil particles were not adequately bonded together. The admixed materials failed by surface erosion caused by inadequate bonding of soil particles.

Treated samples that survived the air impingement test were set aside to cure at ambient temperatures in the laboratory for a period of 16 hours, and then they were subjected to a water erosion test. This test was conducted to determine each material's ability to resist the detrimental effects caused by rainfall. The materials evaluated for use in a desert climate were subjected to a simulated one in. rainfall and the other materials were subjected to a simulated two in. rainfall. The duration of each simulated rainfall was one hour. The erosion test apparatus (Photograph 5) consisted of a rotating table located under a water reservoir designed to maintain a constant 6 in. head of water. Rainfall was simulated by piping water through 12 shower heads attached to the bottom of the reservoir and located 14 in. above the surface of the treated soil samples. The amount of rainfall could be controlled by adjusting the flow through the shower heads. If erosion occurred during the test, the treated sample was considered failed.

Samples surviving the water erosion test were resubjected to the air impingement test. Samples that survived these airblast test were next evaluated for resistance to POL spillage. Five milliliters of JP-4 fuel were poured onto the center of each treated sample and allowed to air dry for 24 hr. After the 24 hr, the samples were again placed under the sun lamps for 4 hr at 100 or 120°F, then removed and once again subjected to the air impingement test. The materials that passed these tests were considered for large scale field evaluation.

Test Results

The performance of each product was recorded as it was tested in the laboratory. The performances of the products were compared by using five parameters selected to evaluate the performance of each product. A maximum

value or grade was assigned to each parameter based on its importance when used by military personnel in a mission area. The parameters and their assigned values are as follows:

Parameter	Value
Surface condition	5
Resist 50 MPH air velocity	40
Resist 100 MPH air velocity	25
Resist water erosion	10
Resist POL spillage	20

If the performance of a product in a specific category was less than 100 percent, it scored less than the maximum value assigned that parameter. Table 2 list the score of each material evaluated for use in desert climates, and Table 3 list the score of each material evaluated or use in tropic and temperate climates.

As shown in Table 2, scores for the performance of the materials ranged from 0 to 100. No score was listed for one material because it could not be applied to the soil sample as recommended by the manufacturer. The product had cured in its shipping container to the point where it could not be diluted with water. Although one material could be mixed with water as recommended, it scored zero points because it was impossible to obtain uniform coverage when it was applied to the surface of the soil samples. A minimum score of two or three indicated the material could be diluted and applied as recommended, but after the product began to cure, voids occurred in the surface film and there was no possible way the material would provide any type of dust suppression.

Scores of the materials tested for use in tropic and temperate climates are shown in Table 3. The scores for these materials ranged from 57 to 100. No score was indicated for one material because the emulsion had separated and could not be diluted with water as recommended by the manufacturer. None of the materials scored extremely low because those that scored low in Table 2 and obviously would not be effective in tropic or temperate climates were eliminated from these tests.

3 Field Tests

Field tests were conducted only on the materials submitted for use in desert climates. As in the laboratory evaluation of the materials, the performance of the materials was compared to that of CSS-1 emulsified asphalt. No field tests were planned for the materials submitted for use in tropic and temperate climates. It was felt that the experience and information obtained during laboratory evaluation of all of the materials and field testing of the materials submitted for use in desert climates was adequate for deciding which materials would perform adequately in tropic and temperate climates.

Materials Tested

Materials listed in Table 2 considered for field evaluation were those recommended for nontrafficked areas and scored a minimum of 97 points, those recommended for roadways and scored a minimum of 95 points, and those recommended for helicopter landing pads and scored a minimum of 99 points. This list of materials was reduced to four for use on nontrafficked areas, seven for roadways, and three for helicopter landing pads. The list was reduced after costs of each product, equipment required for application, and mixing instructions were considered. Although Benebind 4D was not recommended by the supplier to be used on nontrafficked areas, it was also selected based on its performance during the laboratory tests and its very inexpensive cost. Since CSS-1 cost approximately $1.50 per square yard to apply to roadways and helipads in Saudi Arabia, this was considered as the approximate maximum cost for a material. Any material that required application equipment that was not readily available to military engineers, and materials that contained multiple components that required precise mixing procedures were eliminated from the list. The selected materials and their areas of application are listed in the following table.

Materials Selected for Field Evaluation			
	Area of Application		
Product	Nontrafficked	Roadways	Helipads
Benebind, 4D	X	X	X
Lignosite Road Binder, 9B	X		
Lignosite Road Binder, 9C		X	X
Sandstill, 12A	X		
Sandstill, 12B		X	
Sandstill Instapave, 13		X	
Sand Glue, 14A	X		
Sand Glue, 14C		X	
Sand Glue, 14D			X
Road Oyl, 18A		X	
Enduraseal 200, 21A		X	

Construction of Test Sections

Yuma Proving Ground (YPG), AZ was selected as the test site for conducting the field evaluation of the dust control materials. YPG was selected because it is located in a desert, the soil is very similar to the desert soils of the Middle East, and test vehicles were available to apply traffic to the test sections. YPG provided support for preparation and construction of the test sites, collection of weather data, and collection and measurement of dust particles generated during the traffic tests. Preparation of the test areas included grading the areas with a motor grader to remove vegetation and provide a smooth surface for the application of the dust control materials. After the test sections were prepared, each test item was located and marked with stakes based on predetermined dimensions listed in the plan of test.

Five helicopter landing pads, each 150- by 150-ft, were prepared. Three of the pads were located in one area, and the other two were located in another area. A typical layout of two helipads is shown in Figure 7. Each pad was separated by a minimum distance of 150 ft so traffic conducted on one pad would not influence the performance of another pad. Three of the pads were treated with materials that passed the laboratory tests, one pad was treated with CSS-1 emulsified asphalt, and the fifth pad remained untreated so comparisons of the performance of treated versus nontreated pads could be made. Photograph 6 shows one of the helipads after it had been cleared of all vegetation and graded with a motor grader. The surface of the pad was prewet with water at a rate of 0.10 to 0.20 gal/sq yd, as shown on Photograph 7, to break the surface tension. Prewetting was required so a uniform coverage of the dust control materials could be obtained. Immediately after prewetting

was completed, a dust control material was applied to the surface of the test item with a common asphalt distributor as shown on Photograph 8. Prior to applying any of the materials, the pump on the distributor was modified, as shown in Figure 8, to permit external lubrication. External lubrication of the pump is required prior to applying a material if it is not a natural lubricant. As shown in the foreground of photograph 8, a shallow ditch was constructed around the edge of each helipad to provide drainage.

Two roadway test sections were constructed, one was trafficked with a 5 ton M927 truck and the other was trafficked with a M2 Bradley Infantry Fighting Vehicle. As shown in Figure 9, each test section was 1,800 ft long by 20 ft wide and contained nine 200 ft long test items. Eight of the items were treated with dust control materials, and one remained untreated for comparison purposes. Photograph 9 shows one of the test sections after the vegetation had been removed and the surface graded smooth. Photographs 10, 11, and 12 show one of the materials being applied to a 200 ft long test item, admixed into the soil with the blade of a motor grader, and compacted with a pneumatic-tire roller. Drainage ditches were constructed along these test sections to control runoff if heavy rainfall occurred.

Four nontrafficked test pads, 50- by 50-ft, were constructed and treated with dust control materials as recommended by their suppliers. As shown in Figure 10, the pads were separated with a 25 ft wide buffer zone. Since these pads were located at the same site, a drainage ditch was constructed around all four pads.

A brief description of the dilution rates and procedures for applying dust control products to each test item is listed in Table 4.

Test Vehicles

Three military vehicles were used to apply traffic to the test items. A UH-1 Huey helicopter as shown in Photograph 13 was used to apply traffic to the helipads. The total takeoff weight of the Huey was 8,269 lb. The helicopter operations conducted on each helipad were as follows:

a. Approach the center of the helipad and hover approximately 5 ft above the helipad for one minute.

b. Land on the helipad and idle the engines for one minute.

c. Generate power and perform a takeoff.

Five operations of the above sequences were performed on each helipad before moving to another pad.

The roadway test items in one test section were trafficked with a M927 truck. As shown on Photograph 14, this was a 6X6, 5 ton, dual-axle truck

that weighed 25,035 lb. Each 14.00 R 20, 18 ply tire was inflated to a pressure of 55 psi. Traffic during a test period included 25 passes of the truck. This was accomplished by traversing the section in one direction, and then turning the truck around and traversing the section in the opposite direction. The test vehicle traversed the test section at approximately 15 mile per hour.

The test items in the other roadway test section were trafficked with a M2 Bradley Infantry Fighting Vehicle as shown on Photograph 15. The Bradley which is a tracked vehicle weighed 54,150 lb. Twenty-five passes of the Bradley were applied to the test section during each test period. The passes were applied in the same manner as was done with the truck, and the approximate speed of the Bradley was also 15 miles per hour.

Collection of Data

The native soil in the area where the test sites were located was classified as a nonplastic SP sand, as shown on Figure 3. The bearing strength of the soil was determined with a dynamic cone penetrometer. Data obtained from the wheeled vehicle roadway test section are shown on Tables 5 and 6, and plots of the California Bearing Ratio (CBR) versus depth are shown in Figure 11. These data are representative of the soil strength for all of the test sites.

The performance of each dust control material was documented by recording visual observations in a field notebook as traffic tests were being conducted and after the tests were completed. A video camera and 35 mm camera were used to obtain video tape and photographs of the performance of the materials. As shown on Photograph 16, a six ft long board was installed vertically along the edge of each roadway test item at the center of the item. The boards were painted white and marked with black symbols and numbers so the height and density of the dust clouds generated by the traffic vehicles could be determined. These boards were also placed on the edge of each helipad.

As shown in Figures 7 and 9, dust collectors were placed on the corners of each helipad and the midpoint of each roadway test item to collect dust particles while traffic was being applied to the item. One of the dust collectors installed on the edge of a roadway test item is shown on Photograph 16. A closeup of the filter on a dust collector is shown on Photograph 17. The collectors were General Metal Works Inc. model GMWL 2000 high volume air samplers. They were designed to accurately measure airborne particulate matter utilizing 8 in. by 10 in. filter paper that traps particles as small as 0.01 micron in size. Each sampler was mounted on a model GMWT 2200 tripod that positioned the filter 42 in. above the ground.

Extensive climatological data was collected daily by the Yuma Meteorological Team at YPG. A monthly summary of the data collected during the test period is shown in Table 7.

Traffic Tests and Results

Traffic tests were conducted in May, July, and September 1992. During each period, the tests consisted of traffic as described in the paragraph entitled "Test Vehicles." When traffic tests were not being conducted, the sections were marked with surveying ribbon and signs to discourage unauthorized traffic. Visual inspection of each test item prior to traffic tests indicated the only item that had received any unauthorized traffic during the entire test period was the nontraffic test item treated with Sand Glue. Ruts similar to those made by a 5 ton truck were noticed traversing across one corner of the pad prior to the July traffic tests.

Helipad test items

Prior to conducting any traffic tests on the treated helipads, the pads were visually inspected to determine how the materials withstood natural weathering conditions. The only evidence of a dust control material on the Benebind treated pad was material that had puddled in ruts when it was applied in December. Vegetation had also begun to grow on the pad. The surfaces of the other treated pads were hard, looked good, and there was no evidence of vegetation. Some loose sand and soil particles had accumulated on each of the surfaces. It is believed that this loose material was a result of particles becoming airborne during windy conditions and then being deposited on the pads as the wind subsided.

During initial helicopter traffic, three of the materials performed well and one of the materials failed during the first decent of the helicopter. Traffic tests were discontinued on the Benebind treated helipad after the first decent of the helicopter. Results of the visual inspections of the treated pads after each sequence of traffic are listed in Table 8. As indicated in the table, Sand Glue and Lignosite treated helipads performed as well as the CSS-1 treated helipad during the three test periods. Table 9 summarizes the data collected with the dust collectors during the test periods. These results also indicate that the Sand Glue and Lignosite performed as well as the CSS-1. A comparison of the total amounts of dust particles collected during the May tests indicated that the dust control materials were six times more effective than no material, and they were also very effective during the July and September tests. Photograph 17 shows a helicopter hovering above one of the treated helipads and Photograph 18 shows the dust generated by a helicopter hovering above the nontreated helipad.

Wheeled-vehicle roadway test section

Visual inspection of the wheeled-vehicle traffic test items prior to traffic revealed that vegetation was growing in four of test items. These items were Sand Glue, Sandstill, Instapave, and Benebind. There was no dust control material evident on the Enduraseal or Benebind treated items. The Sand Glue,

Road Oyl, CSS-1, and Lignosite treated items were very firm and their surfaces were hard.

During the first few passes of the 5 ton truck on the test section, dust began to develop on the test items treated with Enduraseal 200 and Benebind. By the time twenty-five passes were completed, these two items looked as if there had been no product applied to them, and they were considered failed. Results of visual inspections of the test items after each test period are shown in Table 10. As traffic was continued during the July and September tests, the Sandstill Instapave treated item failed and conditions of the items treated with Sand Glue, Road Oyl, and Sandstill deteriorated, but these three products still provided dust proofing capability. The items treated with CSS-1 and Lignosite Road Binder withstood all of the traffic that was applied during the three test periods.

Table 11 provides a summary of the data obtained by the dust collectors during the three test periods. This data may not be completely accurate because some of the dust particles generated on the poorer performing test items may have been collected in the collectors positioned on adjacent items. An example of this is shown by the amount of dust collected during the May tests in the collector positioned on the edge of the CSS-1 treated item. Some of these dust particles may have been generated on the Enduraseal 200 treated item. Comparison of the total amounts of dust particles collected on the treated items to the dust collected on the nontreated item clearly indicates that seven of the products provided some measure of dust control. Four of these products (Sandstill, Lignosite Road Binder, Road Oyl, and Sand Glue) performed as well or better than the CSS-1 emulsified asphalt.

Tracked-vehicle roadway test section

Visual inspection of the test items prior to traffic revealed that the condition of these items were essentially the same as those in the wheeled-vehicle test section. Results of visual inspections of the test items after each test period are shown in Table 10.

During the first pass of the Bradley, there was no visual difference in the amount of dust generated on the nontreated, Enduraseal 200 treated, or Benebind treated test items. As the number of passes of the Bradley increased to twenty-five, dust generated on the Sand Glue, Road Oyl, Sandstill, and Sandstill Instapave treated items increasingly became worse. The items treated with CSS-1 and Lignosite Road Binder provided dust proofing capabilities throughout the first twenty-five passes of the Bradley. Inspection of these test items after the twenty-five passes were completed revealed that deep ruts had developed in the nontreated, Enduraseal 200, and Benebind treated items, and there was no dust control product evident on the surface of either of these treated items. Less rutting occurred in the items treated with Sand Glue, Road Oyl, Sandstill, and Sandstill Instapave, and there was some dust control product remaining on the surface of each of these items. But, there was not enough product remaining on any of these items to be considered effective.

Very little rutting occurred in the items treated with CSS-1 or Lignosite Road Binder. Some abrasion was noticed on the surfaces of these items, but the soil beneath their surfaces was firm and these products were considered effective.

During the July traffic tests, the items treated with CSS-1 and Lignosite Road Binder provided some measure of dust control when compared to the items that had previously failed. But, the surfaces of these items were beginning to break up and ruts were developing in the traffic area. After these tests were completed, the condition of these two items was considered fair. Traffic was not continued on the test section in September because visual inspection of the two remaining items prior to traffic indicated there was not enough dust control product remaining on either item to consider them effective.

A summary of the data obtained with the dust collectors during the May and July test periods is shown in Table 11. As discussed previously, this data may not be completely accurate, but these results also indicate that CSS-1 and Lignosite Road Binder were the better performing products. This is consistent with the visual observations made during the tests.

Nontrafficked test items

Performance of the products used to treat these items was determined by visual inspection of the surface of each item during the three test periods. A summary of the results of the visual inspections is shown in Table 12. Visual inspection of the test items in May revealed that vegetation was growing on all four of the test items. Two of the products, Benebind and Lignosite Road Binder, had deteriorated to the point that there was no evidence of the products on the surface of the test items. The other two products, Sandstill and Sand Glue, provided a thin crust (approximately 1/16 in. thick) of bonded soil particles on the surface the test items. During the July inspection, ruts were found on the corner of the Sand Glue test item. The ruts looked like they were made by a 5 ton truck or some similar wheeled vehicle. The crusts mentioned previously were still evident during the inspections conducted in July and September. Therefore, Sandstill and Sand Glue were considered to be still effective.

Selection of Products for Use in Tropic and Temperate Climates

Instead of conducting field tests on the products submitted for use in tropic and temperate climates, results of the laboratory tests shown in Table 3 and experience gained during the field evaluation tests conducted at YPG were used to select candidate products. Final determination of products for use in each mission area was made by comparing material cost, mixing instructions, and equipment required to apply the product. If the material cost of a product was more than $1.50 per square yard (the cost of CSS-1), it was not selected

for further consideration. If a product required equipment other than what is organic to an engineer unit, it was also eliminated.

Helipads

As shown in Table 3, Benebind, Lignosite Road Binder, Dirt Glue, and CSS-1 scored 95 or more points. Although Benebind scored high, this product did not perform well during the field tests conducted at YPG; therefore, it was eliminated from further consideration. Dirt Glue is essentially the same material as Sand Glue which performed well during the YPG tests, and Lignosite Road Binder and CSS-1 performed well during the YPG test. These three products should be effective in tropic and temperate climates.

Wheeled-vehicle roadways

Results of the laboratory tests indicated that seven of the products scored 86 points or more. Three of these products, Benebind, Sandstill Instapave, and Enduraseal 200, performed poorly during the YPG tests and were eliminated from further consideration. The other four products, Lignosite Road Binder, Dirt Glue, Road Oyl, and CSS-1, performed well during the YPG tests and should be effective in tropic and temperate climates.

It was interesting to note that the magnesium chloride and calcium chloride products scored 70 points, and they all failed during the water erosion tests. Both of these products have been proven to be effective on unsurfaced roads and C-130 runways located in temperate climates[1], but their effectiveness decreases after a heavy rain because the material is leeched from the treated soil.

Another interesting note was that the calcium chloride flakes, Dowflake, performed as well as the liquid product, Liquidow. During the tests, the flakes were applied to the surface of the soil samples in a similar manner as fertilizer would be applied to an area. After the flakes were applied, the surface of the samples were sprayed with water at a rate of approximately 0.10 gal/SY.

Tracked-vehicle roadways

Based on observations made when the M2 Bradley was trafficking on the test items at YPG, none of the products evaluated in the laboratory would be effective for controlling dust on areas trafficked by tracked vehicles.

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[1] Armstrong, J. P. (1987). "Dustproofing Unsurfaced Areas: Facilities Technology Application Test (FTAT) Demonstration, FY 86," Miscellaneous Paper GL-87-19, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Nontrafficked test items

As shown in Table 3, three products performed well during the laboratory tests and each scored 97 points. Polybilt 4178 was eliminated from further consideration because its material cost was 6-10 times more expensive than the other two products. Lignosite Road Binder did not perform well during the YPG tests, therefore it was also eliminated from further consideration. Since Dirt Glue is very similar to Sand Glue, and Sand Glue performed fair during the YPG tests, Dirt Glue should be effective for controlling dust on nontrafficked areas.

Discussion of Results

As stated in the purpose of this report, the goal was to reduce manpower, equipment, and logistics requirements of currently approved or recommended dust control materials by 30 percent. In order to compare the products recommended for inclusion into the Army system with currently approved products, Table 13 was developed. This table lists the application rate of each material in pounds of concentrate required to treat one square yard of the applicable mission area. The first four products are the new products, and the last four are products that have been in the system for a long period of time. Sand Glue/Dirt Glue and DCA-1295 are comparable because they are applied by the surface penetrant method; the other products are applied by the admix method.

As shown in Table 13, when treating nontrafficked areas, only 0.12 lbs/SY of Sand Glue/Dirt Glue is required as compared to 0.67 lbs/SY of DCA-1295. This is a reduction of 82 percent in weight. There is a weight reduction of 38 percent when comparing these products applied to roadways, but an increase of 20 percent when comparing them applied to helipads. When using DCA-1295 on roadways and helipads, a fiberglass scrim is placed on the soil surface prior to applying the liquid material. This procedure requires an additional two men and another piece of equipment which increases the manpower and equipment requirements by 30 to 50 percent when compared to the requirements for applying Sand Glue/Dirt Glue.

The requirements for Sandstill, Road Oyl, and emulsified asphalt can be compared because they are all liquid materials that are admixed into the soil. As shown in the table, there is an approximate 30 percent reduction in weight of material requirements when applying Sandstill or Road Oyl as compared to an emulsified asphalt to a roadway. The table also indicates that 3.8 times more Sandstill is required than emulsified asphalt when treating nontrafficked areas.

Lignosite Road Binder, portland cement, and lime are normally supplied in a dry form, shipped in bags or bulk containers, and admixed into the soil. Therefore, the weight, manpower, and equipment requirements were compared. As shown in the table, a 50 percent weight reduction is achieved when

using Lignosite Road Binder as compared to portland cement or lime. The Lignosite Road Binder must be mixed with water before it is applied to the soil, and the portland cement and lime must be distributed onto the soil in dry form before they are admixed. Therefore, it is assumed that the manpower and equipment requirements for these three products are essentially the same since the same equipment and procedures are required to admix and compact the treated soil.

4 Conclusions and Recommendations

Conclusions

Conclusions based on the results of laboratory and field tests conducted during this investigation are as follows:

a. The laboratory tests conducted to simulate field conditions such as rainfall, sun light, heat, POL spillage, wind, and the airblasts from C-130 aircraft and UH-1 helicopters provided an effective and economical procedure for comparing the performances of the dust control products.

b. In most cases the results of the laboratory tests provided an accurate indication of product performance in the field. But, sometimes this was not true. For instance, Benebind scored 100 points when it was evaluated in the laboratory for use on helipads located in a desert climate, and it appeared to be an ideal product for use on roadways and nontrafficked areas also. Therefore, it was selected for field evaluation on all three areas at YPG. Due to this product's poor performance in the field, it was considered failed after the first cycle of tests were completed.

c. Laboratory test results indicated five products recommended for use in desert environments on nontrafficked areas should be considered for field testing at YPG, and three products should be considered for use in tropic and temperate climates.

d. Laboratory test results indicated thirteen products should be considered for further evaluation on roadway test sites at YPG, and seven products should be considered for use in tropic and temperate climates.

e. Laboratory test results indicated seven products should be considered for further evaluation on helicopter test items at YPG, and four products should be considered for use in tropic and temperate climates.

f. Sandstill and Sand Glue performed the best of the four products applied to nontrafficked areas at YPG.

g. Four products, Sand Glue, Road Oyl, Lignosite Road Binder, and Sandstill, withstood the M927 truck traffic conducted on the roadway test site at YPG.

h. None of the products withstood the M2 Bradley traffic.

i. Sand Glue and Lignosite Road Binder treated helipad test items withstood the UH-1 helicopter traffic.

j. The CSS-1 emulsified asphalt was as effective on the wheeled-vehicle roadway test section and helipad test item as any of the products tested.

k. Dirt Glue should be the most effective dust control product of those evaluated for use on nontrafficked areas located in tropic or temperate climates.

l. Lignosite Road Binder, Dirt Glue, Road Oyl, and CSS-1 should be effective on wheeled-vehicle roadways located in tropic and temperate climates.

m. None of the products evaluated will be effective on tracked-vehicle roadways.

n. Lignosite Road Binder, Dirt Glue, and CSS-1 should be effective on helipads located in tropic and temperate climates.

o. The logistic requirements for Lignosite Road Binder, Sandstill, Sand Glue/Dirt Glue, Road Oyl are generally more than 30 percent less than the requirements for similar products currently in the system.

p. The manpower and equipment requirements for Sand Glue/Dirt Glue are less than those for DCA-1295.

q. The manpower and equipment requirements for Lignosite Road Binder are essentially the same as the requirements for lime or portland cement.

Recommendations

It is recommended that TM 5-830-3, "Dust Control for Roads, Airfields, and Adjacent Areas" be revised to include the following dust control products and respective areas of application applied at the rates listed in tne text of this report.

a. Sandstill and Sand Glue will control dust on nontrafficked areas located in desert climates.

b. Sand Glue, Road Oyl, Lignosite Road Binder, and Sandstill will control dust on wheeled-vehicle roadways located in desert climates.

c. Sand Glue and Lignosite Road Binder will control dust on helipads located in desert climates.

d. Dirt Glue will control dust on nontrafficked areas located in tropic and temperate climates.

e. Lignosite Road Binder, Dirt Glue, and Road Oyl will control dust on wheeled-vehicle roadways located in tropic and temperate climates.

f. Lignosite Road Binder and Dirt Glue will control dust on helipads located in tropic and temperate climates.

Bibliography

Carr, J. W. (1973). "Surface Velocities and Temperature Changes for C-130, C-141, and C-5A Exhaust Blast and C-5A Wing-tip Vortex," Miscellaneous Paper S-73-61, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Departments of the Army and the Air Force. (1987). "Dust Control for Roads, Airfields, and Adjacent Areas," Technical Manual TM 5-830-3, Washington DC.

Leese, G. W. (1964). "Helicopter Downwash Blast Effects Study," Technical Report 3-664, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Leese, G. W. (1972). "UH-1H Downwash Velocity Measurements," Miscellaneous Paper S-72-31, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Leese, G. W. and Knight, J. T. (1974). "Helicopter Downwash Data," Miscellaneous Paper S-74-17, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Styron, C. R. and Eaves, R. C. (1973). "Investigation of Dust Control Materials," Miscellaneous Paper S-73-70, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Table 1
Identification of Dust Control Materials for Laboratory Evaluation Tests

WES Lab No.	Supplier and Address	Supplier Designation	General Description
1A 1B	Albright Seed Company, Inc. 487 Dawson Drive, Bay 55 Camarillo, CA 93012	Sentinel	Hydrophilic colloid
2A 2B	Amtrade, Inc. 8150 Holton Drive Florence, KY 41042	Petro D-Dust	Methyl lardate
3A 3B	Bartlett Services, Inc. 60 Industrial Park Road Plymouth, MA 02360	Polymeric Barrier System	Acrylic latex
4A 4B	Benetech, Inc. 1750 Eastwood Drive Aurora, IL 60506	Dust Tarbt	Aqueous acrylic emulsion
4C 4D	Benetech, Inc. 1750 Eastwood Drive Aurora, IL 60506	Benebind	Tall oil pitch emulsion
5A 5B 5C	Brown Industrial Process Corp P.O. Box 28155 San Diego, CA 92128	BIPCO 282	Acrylic copolymer
6	C.S.S. Technology, Inc. P.O. Box 1355 Weatherford, TX 76086	EN-1	Sulfuric acid
7A 7B	Cellulose Resources Corp P.O. Box 1562 Escondido, CA 92025	Fiber Pro	Cellulose

(Sheet 1 of 4)

Table 1 (Continued)

WES Lab No.	Supplier and Address	Supplier Designation	General Description
<u>8A</u> <u>8B</u> <u>8C</u>	DeWitt Company Highway 61 South RR 3 Box 338 Sikeston, MO 63801	Polybilt 4178	Polymer
<u>9A</u> <u>9B</u> <u>9C</u>	Dustpro 2432 W. Peoria, Suite 1160 Phoenix, AZ 85029	Lignosite Road Binder	Calcium lignosulfonate
10A 10B	Earth Systems International,Inc. 28259 Dorothy Drive Agoura Hills, CA 91301	Soil Master WRI	Acrylic copolymer emulsion
<u>11</u>	Earth Systems International, Inc. 28259 Dorothy Drive Agoura Hills, CA 91301	Soil Master WRII A&B	Vinyl acetate
<u>12A</u> <u>12B</u>	Energy Systems Associates, Inc. P.O. Box 976 McLean, VA 22101	Sandstill	Petroleum hydrocarbon emulsion
<u>13</u>	Energy Systems Associates, Inc. P.O. Box 976 McLean, VA 22101	Sandstill Instapave	Petroleum hydrocarbon emulsion
<u>14A</u> <u>14B</u> <u>14C</u> <u>14D</u>	Executive Resource Associates, Inc. Suite 813, One Crystal Park 2011 Crystal Drive Arlington, VA 22202	Sand Glue	Vinyl acrylic copolymer emulsion

(Sheet 2 of 4)

Table 1 (Continued)

WES Lab No.	Supplier and Address	Supplier Designation	General Description
15	Erosion Control Systems, Inc. Suite 180 1800 McFarland Blvd. N. Tuscaloosa, Al 35406	Verdyol Dust Binder	Sodium lignosulfonate
16A 16B	Green Mountain, Inc. 4N250 Route 53 Addison, IL 60101	Mountain Grout	Hydrophobic polyurethane
17	R/M Sciences Inc. 42353 Avenida Alvarado Temecula, CA 92390	US Formula 1202	Sulfuric acid
18A 18B	Soil Stabilization Products Co. P.O. Box 2779 Merced, CA 95344	Road Oyl	Pitch and rosin emulsion
19A 19B	Weather Tect, Inc. 9209 Seminole Blvd. #93 Seminole, FL 34642	Weather Tect	Acrylic copolymer
20A 20B	Ergon Asphalts & Emulsions, Inc. P.O. Drawer 1639 Jackson, MS 39215	CSS-1	Asphalt emulsion
21A 21B 21C	Future Way Enviro Technologies,Inc. 13173 Amble Greene Close White Rock, B.C. V4A 6P9	Enduraseal 200 Enduraseal 100 Enduraseal 300	Gilsonite resin and tall oil pitch
22	Gustafson, Incorporated 1400 Preston Road, Suite 400 Plano, TX 75075	Magna-Coat	Polymer

(Sheet 3 of 4)

Table 1 (Concluded)

WES Lab No.	Supplier and Address	Supplier Designation	General Description
<u>23</u>	Brown Industrial Process Corp. P.O. Box 28155 San Diego, CA 92128	BIPCO 33	Alcohol/petroleum solvents/polyamide resin
24	P Q Corporation P.O. Box 840 Valley Forge, PA 19482	Sodium Silicate	Silicic acid, sodium salt
<u>25</u>	Cargill Solarchem Resources P.O. Box 364 Newark, CA 94560	Dust-Off	Magnesium chloride
<u>26</u>	Weather Tect, Inc. 9209 Seminole Blvd. #93 Seminole, FL 34642	Weather Tect MSS	Acrylic copolymer
<u>27</u>	Earth Systems International, Inc. 28259 Dorothy Drive Agoura Hills, CA 91301	Soil Master WR	Acrylic copolymer emulsion
<u>28</u>	RDE, Inc. 101 North Virginia Street Crystal Lake, IL 60014	Molex	Condensed molasses
<u>29A</u> <u>29B</u> <u>29C</u>	Ashland Chemical Company P.O. Box 10298 Jackson, MS 39209	Liquidow Dowflake Dowflake	Calcium chloride Calcium chloride

(Sheet 4 of 4)

Table 2
Laboratory Test Results, Dust Control Materials Recommended

Product	Surface (5)	50 mph (40)	100 mph (25)	Erosion (10)	POL (20)	Total (100)
Nontrafficked Areas (Desert Climates)						
Sentinel, hydrophilic colloid	3					3
Petro D-Dust, fatty oil	4	40				44
Polymeric Barrier System, acrylic latex	5	40	25	10	20	100
Dust Tarbt, aqueous acrylic emulsion	2	20				22
Fiber Pro, cellulose	0					0
Polybilt 4178, polyacrylate	2	40	15			57
Lignosite Road Binder, calcium lignosulfonate	5	40	25	9	20	99
Soil Master WR I, copolymer methacrylate and acetes						
Sandstill, petroleum hydrocarbon emulsion	5	40	25	10	20	100
Sand Glue, vinyl acrylic copolymer emulsion	4	40	25	10	20	99
Dustbinder, sodium lignosulfonate	4	40	25			69
Mountain Grout, hydrophobic polyurethane	2	40	25	10	20	97
US Formula 1202, sulfuric acid	5					5
Weather Tect, acrylic copolymer	3	40	20			63
CSS-1, emulsified asphalt	4	40				44
Magna-Coat, polymer	5	40				45
Roadways Trafficked by Wheeled and Tracked Vehicles (Desert Climates)						
Polymeric Barrier System, acrylic latex	5	40	25	10	20	100
Benebind, tall oil emulsion	2	40				42
Bipco 282, acrylic copolymer epoxy	5	40	25	10	20	100
EN-1, sulfuric acid	5	40	25			70
Polybilt 4178, polyacrylate	5	40	25	10	20	100
Lignosite Road Binder, calcium lignosulfonate	5	40	25	9	20	99
Soil Master WR II A&B, copolymer methacrylate and acetes	5	40	25	9	20	99

(Continued)

Table 2 (Concluded)

Product	Surface (5)	50 mph (40)	100 mph (25)	Erosion (10)	POL (20)	Total (100)
Roadways Trafficked by Wheeled and Tracked Vehicles (Desert Climates) (Continued)						
Sandstill, petroleum hydrocarbon emulsion	5	40	22	9	20	96
Sandstill Instapave, petroleum hydrocarbon emulsion	5	40	25	10	20	100
Sand Glue, vinyl acrylic copolymer emulsion	5	40	25	10	20	100
Mountain Grout, hydrophobic polyurethane	5	40	25	10	20	100
Road Oyl, pitch and rosin emulsion	5	40	25	10	20	100
Weather Tect, acrylic copolymer	5	40	25	5	20	95
CSS-1, emulsified asphalt	5	40	25	7	20	97
Roadways Trafficked by Wheeled and Tracked Vehicles (Desert Climates)						
Enduraseal 200, rosin and asphalt emulsion	4	40	23	9	20	96
Enduraseal 100, rosin and asphalt emulsion	4					4
Enduraseal 300, rosin and asphalt emulsion	2					2
Helicopter Landing Areas (Desert Climates)						
Polymeric Barrier System, acrylic latex	5	40	25	10	20	100
Benebind, tall oil emulsion	5	40	25	10	20	100
Lignosite Road Binder, calcium lignosulfonate	5	40	25	9	20	99
Soil Master WR II A&B, copolymer methacrylate and acetes	5	40	25	9	20	99
Sand Glue, vinyl acrylic copolymer emulsion	5	40	25	9	20	99
Mountain Grout, hydrophobic polyurethane	5	40	25	10	20	100
Road Oyl, pitch & rosin emulsion	5	40	15	7	15	82
CSS-1, emulsified asphalt	5	40	25	7	20	97
Nontrafficked Areas (Desert Environments)						
Bipco 33, alcohol, petroleum solvents, polyamide resin	5	40				45
N Sodium Silicate, sodium silicate and hardener	5	40		10	20	75

Table 3
Laboratory Test Results, Dust Control Materials Recommended

Product	Surface (5)	50 mph (40)	100 mph (25)	Erosion (10)	POL (20)	Total (100)
Nontrafficked Areas (Tropic and Temperate Climates)						
Polybilt 4178, polyacrylate	2	40	25	10	20	97
Lignosite Road Binder, calcium lignosulfonate	5	40	25	7	20	97
Soil Master WR I, copolymer methacrylate and acetes	3	20	15	10	10	58
Sandstill, petroleum hydrocarbon emulsion	5	40	25			70
Dirt Glue, vinyl acrylic copolymer emulsion	3	40	25	9	20	97
US Formula 1202, sulfuric acid	5	40	25			70
Weather Tect, acrylic copolymer	3	40	25	10		78
CSS-1, emulsified asphalt	4	40	25			69
Bipco 33, alcohol, petroleum solvents, polyamide resin	4	20	15	10	15	64
Roadways Trafficked by Wheeled and Tracked Vehicles (Tropic and Temperate Climates)						
Benebind, tall oil emulsion	5	40	25	10	20	100
EN-1, sulfuric acid	5	40	20			65
Polybilt 4178, polyacrylate	5	40	25			70
Lignosite Road Binder, calcium lignosulfonate	5	40	25	9	20	99
Soil Master WR II A&B, copolymer methacrylate and acetes	5	40	20			65
Sandstill, petroleum hydrocarbon emulsion	5	40	25			70
Sandstill Instapave, petroleum hydrocarbon emulsion	4	40	20	10	20	94
Dirt Glue, vinyl acrylic copolymer emulsion	4	40	25	10	20	99
Road Oyl, pitch and rosin emulsion	5	40	24	9	20	98
CSS-1, emulsified asphalt	5	40	25	5	20	95
Enduraseal 200, rosin and asphalt emulsion	3	40	23	10	10	86
Enduraseal 100, rosin and asphalt emulsion	4	40	25	8		77
Enduraseal 300, rosin and asphalt emulsion						
Dust Off, magnesium chloride	5	40	25			70

(Continued)

Table 3 (Continued)

Product	Surface (5)	50 mph (40)	100 mph (25)	Erosion (10)	POL (20)	Total (100)
Roadways Trafficked by Wheeled and Tracked Vehicles (Tropic and Temperate Climates) (Continued)						
Soil Master WRI, copolymer methacrylate and acetates	2	20	15	10	10	57
RDE, beet extract	2	40	25			67
Liquidow, calcium chloride	5	40	25			70
Dowflake, calcium chloride flakes and water	5	40	25			70
Dowflake, calcium chloride flakes	5	40	25			70
Helicopter Landing Areas (Tropic and Temperate Climates)						
Benebind, tall oil emulsion	5	40	25	10	20	100
Lignosite Road Binder, calcium lignosulfonate	5	40	25	9	20	99
Soil Master WR II A&B, copolymer .nethacrylate and acetes	5	40	20			65
Dirt Glue, vinyl acrylic copolymer emulsion	4	40	25	10	20	99
Road Oyl, pitch and rosin emulsion	5	40	15			60
CSS-1, emulsified asphalt	5	40	25	5	20	95

Table 4
Product Application Procedures

Product	Nontrafficked Area	Roadway	Helipads
Benebind, 4D	Dilute product 1:4 with water, prewet soil and spray at 0.5 gal/SY	Dilute product 1:4 with water, prewet soil and spray at 0.5 gal/SY	Dilute product 1:4 with water, prewet soil and spray at 0.5 gal/SY
Lignosite Road Binder, 9B	Prewet soil and spray product as received at 1.0 gal/SY		
Lignosite Road Binder, 9C		Prewet soil, spray product as received at 1.0 gal/SY, admix into soil, compact with roller, and spray product at 1.0 gal/SY	Prewet soil, spray product as received at 1.0 gal/SY, admix into soil, compact with roller, and spray product at 1.0 gal/SY
Sandstill, 12A	Dilute product 1:5 with water, prewet soil and spray at 0.77 gal/SY		
Sandstill, 12B		Dilute product 1:5 with water, scarify and prewet soil, spray at 1.55 gal/SY and admix, compact with roller	
Sandstill Instapave, 13		Dilute product 1:2 with water, prewet soil and spray at 0.5 gal/SY	
Sand Glue, 14A	Dilute product 1:40 with water, prewet soil and spray at 0.52 gal/SY		
Sand Glue, 14C		Scarify , prewet soil, dilute product 1:20 with water, spray at 1.05 gal/SY, compact with roller, dilute product 1:10 with water and spray at 0.55 gal/SY	
Sand Glue, 14D			Scarify , prewet soil, dilute product 1:20 with water, spray at 1.68 gal/SY, dilute product 1:10 with water, spray at 0.88 gal/SY, compact with roller, dilute product 1:10 with water and spray at 0.44 gal/SY

(Continued)

Table 4 (Concluded)

Product	Nontrafficked Area	Roadway	Helipads
Road Oyl, 18A		Dilute product 1:5 with water, spray at 1.20 gal/SY and admix into soil, compact with roller, dilute product 1:10 with water and spray at 0.55 gal/SY	
CSS-1, 20B		Scarify soil, dilute product 1:6 with water and spray at 1.8 gal/SY, admix, and compact with roller	Scarify soil, dilute product 1:6 with water and spray at 1.8 gal/SY, admix, and compact with roller
Enduraseal 200, 21A		Scarify soil, dilute product 1:4 with water, spray at 0.44 gal/SY twice, admix, compact with roller, and spray at 0.33 gal/SY	

Table 5
Wheeled Roadway Test Section

DCP DATA SHEET

Project Dust Control   Date Dec. 91
Location Roadway   Soil Type(s)

No. of Blows [1]	Accumulative Penetration mm [2]	Penetr./ Blow Set mm [3]	Penetr./ Blow mm [4]	Hammer Blow Factor [5]	DCP Index [6]	CBR % [7]	Depth in. [8]
0	40	-----	-----	-----	-----	---	0
1	100	60	60.0	1	60.0	3	1.6
1	130	30	30.0	1	30.0	6	3.9
1	155	25	25.0	1	25.0	8	5.1
1	175	20	20.0	1	20.0	10	6.1
1	190	15	15.0	1	15.0	14	6.9
2	230	40	20.0	1	20.0	10	7.5
2	265	35	17.5	1	17.5	12	9.1
2	300	35	17.5	1	17.5	12	10.4

(1) No. of hammer blows between test readings
(2) Accumulative cone penetration after each set of hammer blows
(Minimum penetration between test readings should be 25 mm)
(3) Difference in accumulative penetration (2) at start and end of hammer blow set
(4) (3) divided by (1)
(5) Enter 1 for 17.6 lb hammer; 2 for 10.1 lb hammer
(6) (4) X (5)
(7) From CBR versus DCP correlation
(8) Previous entry in (2) divided by 25.4 rounded off to .1 in.

Table 6
Wheeled Roadway Test Section

DCP DATA SHEET

Project Location: Dust Control Roadway

Date: Dec. 91

Soil Type(s)

No. of Blows [1]	Accumulative Penetration mm [2]	Penetr./ Blow Set mm [3]	Penetr./ Blow mm [4]	Hammer Blow Factor [5]	DCP Index [6]	CBR % [7]	Depth in. [8]
0	45	-----	-----	-----	-----	---	0
1	105	60	60.0	1	60.0	3	1.8
1	135	30	30.0	1	30.0	6	4.1
1	165	30	30.0	1	30.0	6	5.3
1	185	20	20.0	1	20.0	10	6.5
1	205	20	20.0	1	20.0	10	7.3
1	220	15	15.0	1	15.0	14	8.1
2	250	30	15.0	1	15.0	14	8.7
2	285	35	17.5	1	17.5	12	9.8
2	315	30	15.0	1	15.0	14	11.2

(1) No. of hammer blows between test readings
(2) Accumulative cone penetration after each set of hammer blows
(Minimum penetration between test readings should be 25 mm)
(3) Difference in accumulative penetration (2) at start and end of hammer blow set
(4) (3) divided by (1)
(5) Enter 1 for 17.6 lb hammer; 2 for 10.1 lb hammer
(6) (4) X (5)
(7) From CBR versus DCP correlation
(8) Previous entry in (2) divided by 25.4 rounded off to .1 in.

Table 7
Monthly Climatological Summary

Month	Precipitation (in.)	Temperature, °F Max.	Temperature, °F Min.	Temperature, °F Avg.	Relative Humidity, %
December 1991	0.32	75	31	56	54
January 1992	0.84	79	38	54	42
February 1992	1.36	84	46	62	52
March 1992	2.50	84	46	64	58
April 1992	0.65	105	55	77	31
May 1992	0.21	102	63	83	25
June 1992	0.00	109	64	89	17
July 1992	0.00	115	68	94	29
August 1992	2.46	114	70	94	43
September 1992	0.00	109	67	90	32

Table 8
Results of Visual Inspections Helipad Test Items

Product	Condition After First Tests May 1992	Condition After Second Tests July 1992	Condition After Third Tests Sept 1992
Sand Glue	good	good	good
CSS-1	good	good	good
Lignosite	good	good	good
Benebind	failed	-	-

Table 9
Results of Dust Collectors Helipad Test Items

Product	Date	Dust (grams)	Date	Dust (grams)	Date	Dust (grams)
Nontreated	May 1992	3.1 1.6 1.0 <u>0.4</u> 6.1 total	July 1992	0.3 0.4 0.6 <u>1.0</u> 2.3 total	Sept 1992	1.3 1.7 0.3 <u>0.4</u> 3.7 total
Benebind	May 1992	0.6 0.0 0.1 <u>0.3</u> 1.0 total	July 1992	[1]	Sept 1992	[1]
Lignosite	May 1992	0.1 0.2 0.4 <u>0.3</u> 1.0 total	July 1992	0.2 0.2 0.1 <u>0.1</u> 0.6 total	Sept 1992	0.4 0.2 0.1 <u>0.1</u> 0.8 total
CSS-1	May 1992	0.3 0.2 0.2 <u>0.3</u> 1.0 total	July 1992	0.1 0.1 0.1 <u>0.1</u> 0.4 total	Sept 1992	0.1 0.1 0.3 <u>0.0</u> 0.5 total
Sand Glue	May 1992	0.3 0.4 0.1 <u>0.3</u> 1.1 total	July 1992	0.1 0.2 0.1 <u>0.1</u> 0.5 total	Sept 1992	0.0 0.1 0.0 <u>0.1</u> 0.2 total

[1] No product evident on surface of treated area, traffic was discontinued.

Table 10
Results of Visual Inspections Roadway Test Sections

Product	Condition After First Tests May 1992		Condition After Second Tests July 1992		Condition After Third Tests September 1992	
	Wheeled Roadway	Tracked Roadway	Wheeled Roadway	Tracked Roadway	Wheeled Roadway	Tracked Roadway
Sand Glue	good	failed	good	-	fair	-
Road Oyl	fair	failed	fair	-	fair	-
CSS-1	good	good	good	fair	good	[1]
Enduraseal	failed	failed	-	-	-	-
Lignosite	good	good	good	fair	good	[1]
Sandstill	good	failed	fair	-	fair	-
Instapave	poor	failed	poor	-	failed	-
Benebind	failed	failed	-	-	-	-

[1] No product evident on surface of treated area,traffic was discontinued.

Table 11
Results of Dust Collectors

Product	Date	Dust (grams)	Date	Dust (grams)	Date	Dust (grams)	Total (grams)
Wheeled-Vehicle Roadway							
Nontreated	May 1992	2.0	July 1992	1.9	September 1992	1.6	5.5
Benebind		2.0		1.3		2.0	5.3
Instapave		0.7		0.5		1.2	2.4
Sandstill		0.7		0.2		0.8	1.7
Lignosite		0.7		0.1		0.8	1.5
Enduraseal		1.3		0.3		0.9	2.5
CSS-1		1.2		0.1		0.5	1.8
Road Oyl		0.8		0.1		0.3	1.2
Sand Glue		0.6		0.2		0.5	1.3
Tracked-Vehicle Roadway							
Nontreated	May 1992	10.6	July 1992	0.6	Sept 1992	[1]	11.2
Sand Glue		4.8		0.7			5.5
Benebind		3.9		0.8			4.7
Instapave		9.3		0.2			9.5
Sandstill		4.0		0.2			4.6
Lignosite		1.2		0.1			1.3
Enduraseal		2.7		0.6			3.3
CSS-1		1.1		0.2			1.3
Road Oyl		3.9		0.2			4.1

[1] *No product evident on surface of treated area, traffic was discontinued.*

Table 12
Results of Visual Inspections Nontrafficked Test Items

Product	Condition After First Tests May 1992	Condition After Second Tests July 1992	Condition After Third Tests September 1992
Benebind	[1]	[1]	[1]
Sandstill	fair	fair	fair
Lignosite	[1]	[1]	[1]
Sand glue	fair	fair	fair

[1] No product evident on surface of treated area.

Table 13
Weights of Recommended Products and Selected Currently Approved Products

Product	Mission Area (application rate - pounds of concentrate/SY) Nontrafficked	Roadway	Helipads
Lignosite Road Binder		6.00[1]	6.00[1]
Sandstill	1.10	2.17	
Sand Glue/Dirt Glue[2]	0.12	0.92	1.80
Road Oyl		2.00	
DCA-1295[2,3]	0.67	1.50	1.50
Portland Cement		12.00[1]	12.00[1]
Lime		12.00[1]	12.00[1]
Emulsified Asphalt	0.23	3.13	3.13

[1] Weight of dry concentrated product.
[2] Product is applied by surface penetrant method.
[3] This product includes a fiberglass scrim fabric.
[4] The remainder of the products are applied by the admix method.

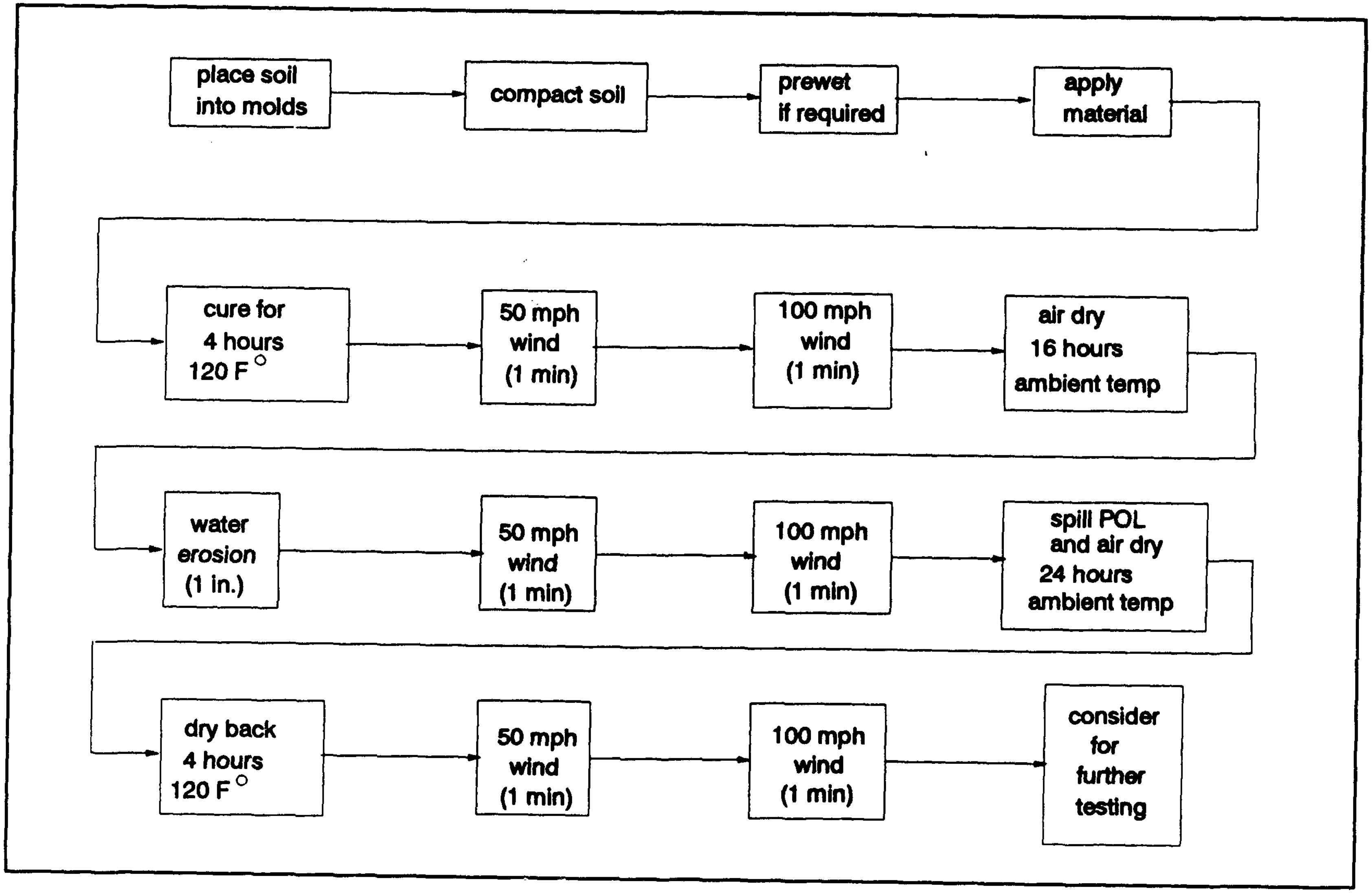


Figure 1. Laboratory test procedures (desert environment)

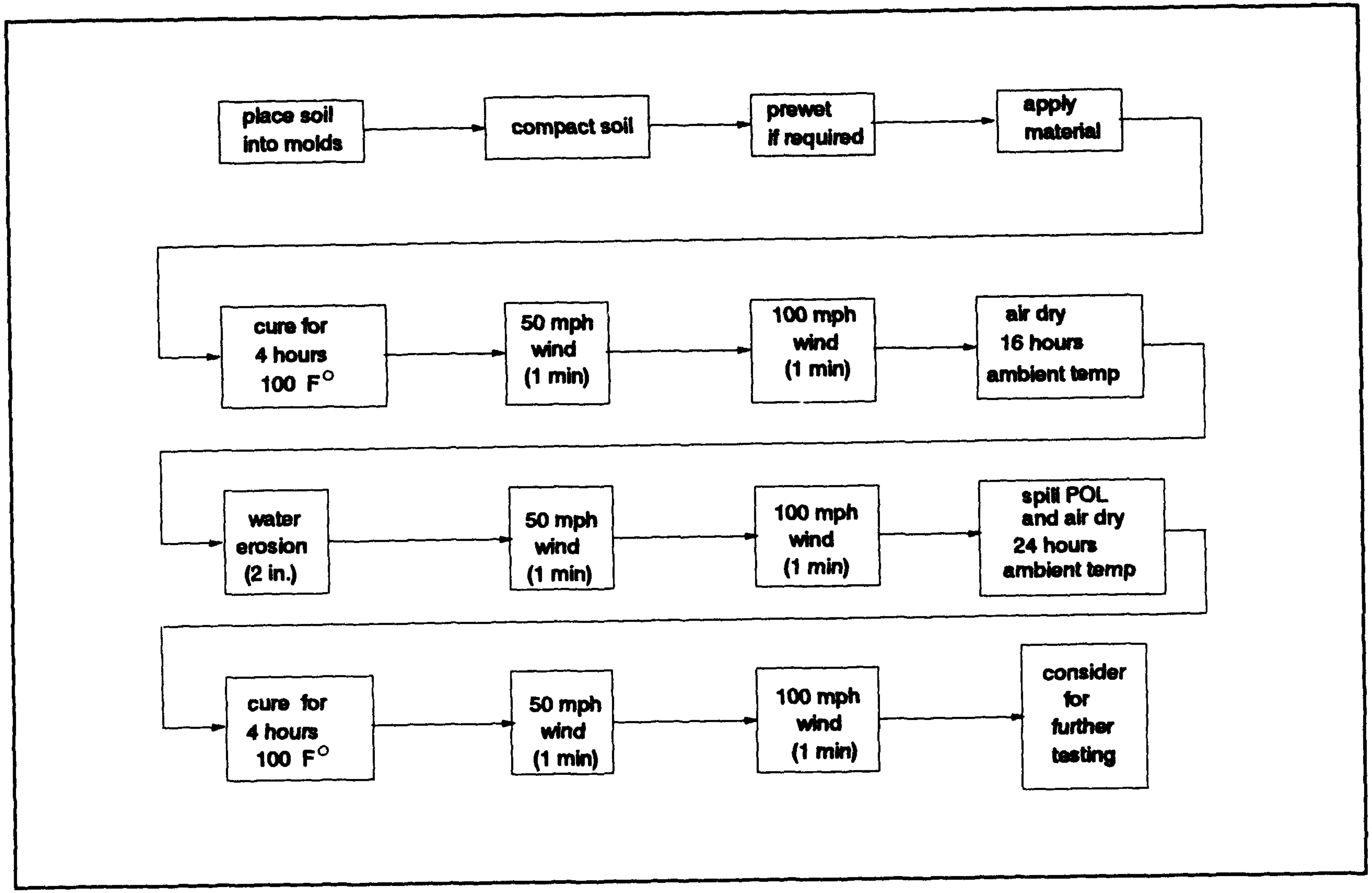


Figure 2. Laboratory test procedures (temperate and tropic environments)

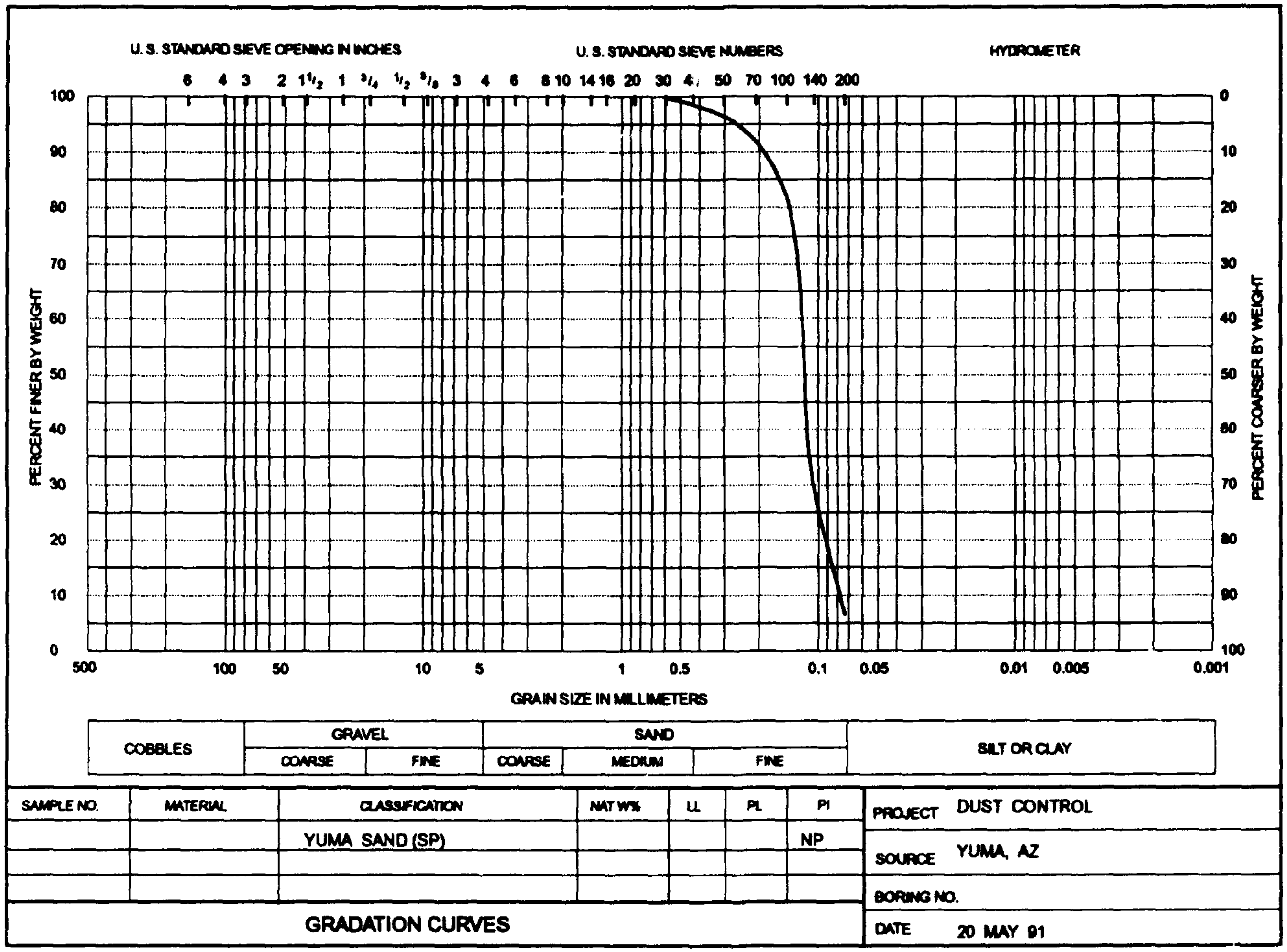
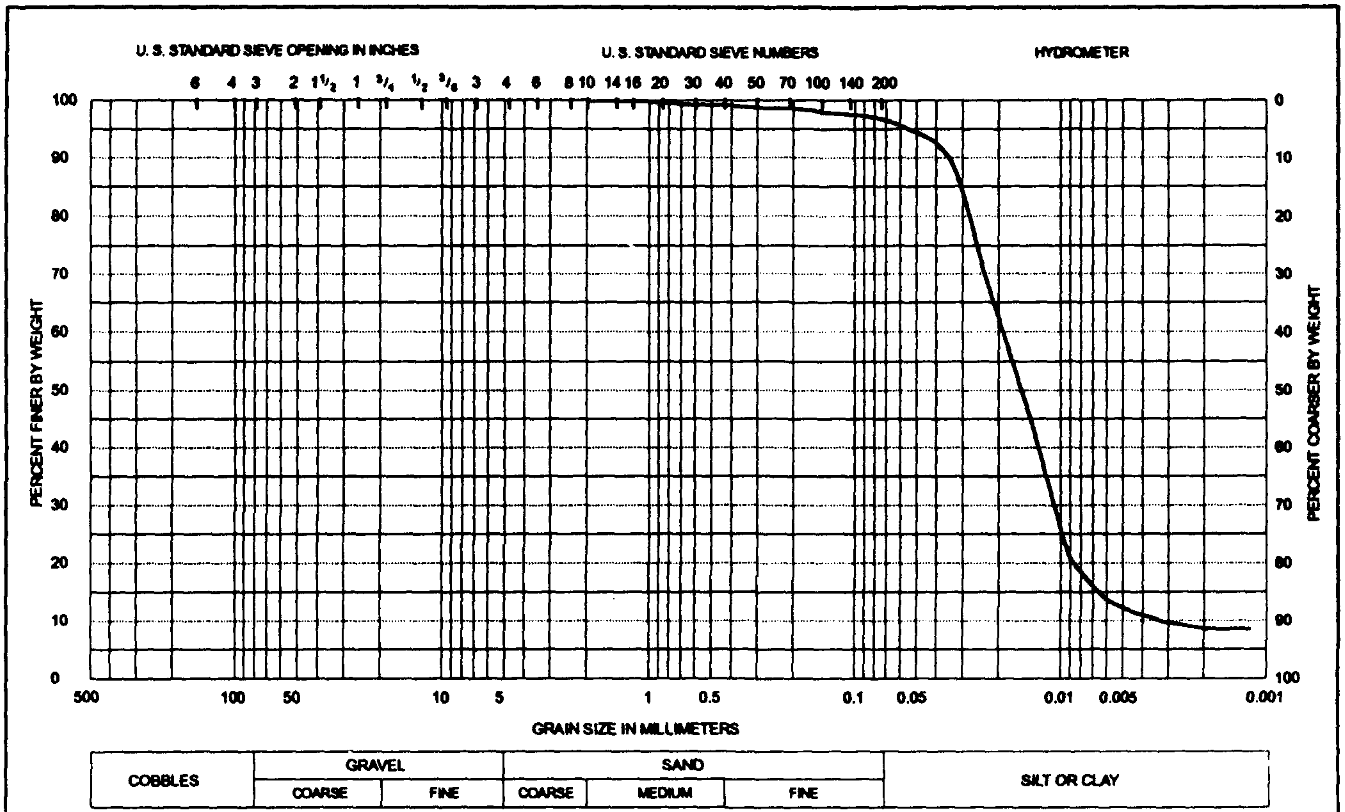


Figure 3. Gradation curve, Yuma sand (SP)



SAMPLE NO.	MATERIAL	CLASSIFICATION	NAT W%	LL	PL	PI
		SILT (ML), BROWN		29	23	6

GRADATION CURVES

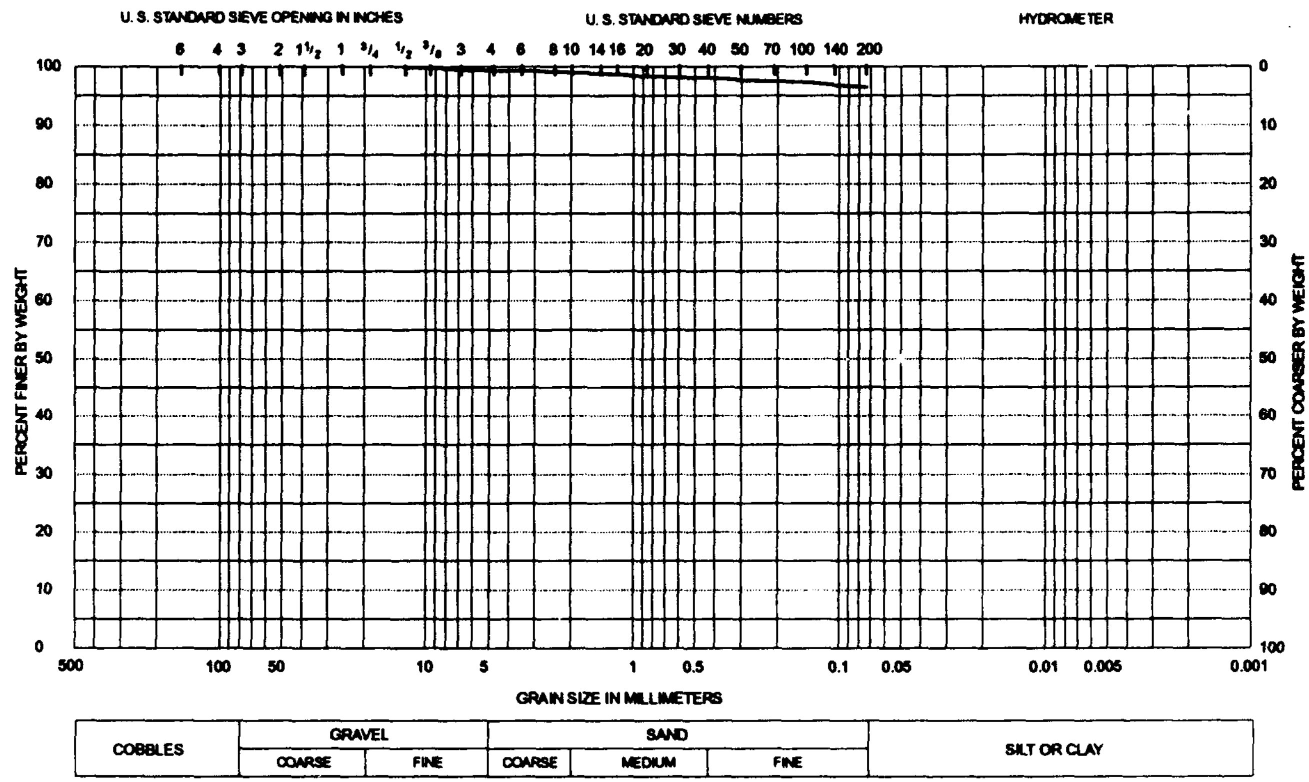
PROJECT DUST CONTROL

SOURCE WES

BORING NO.

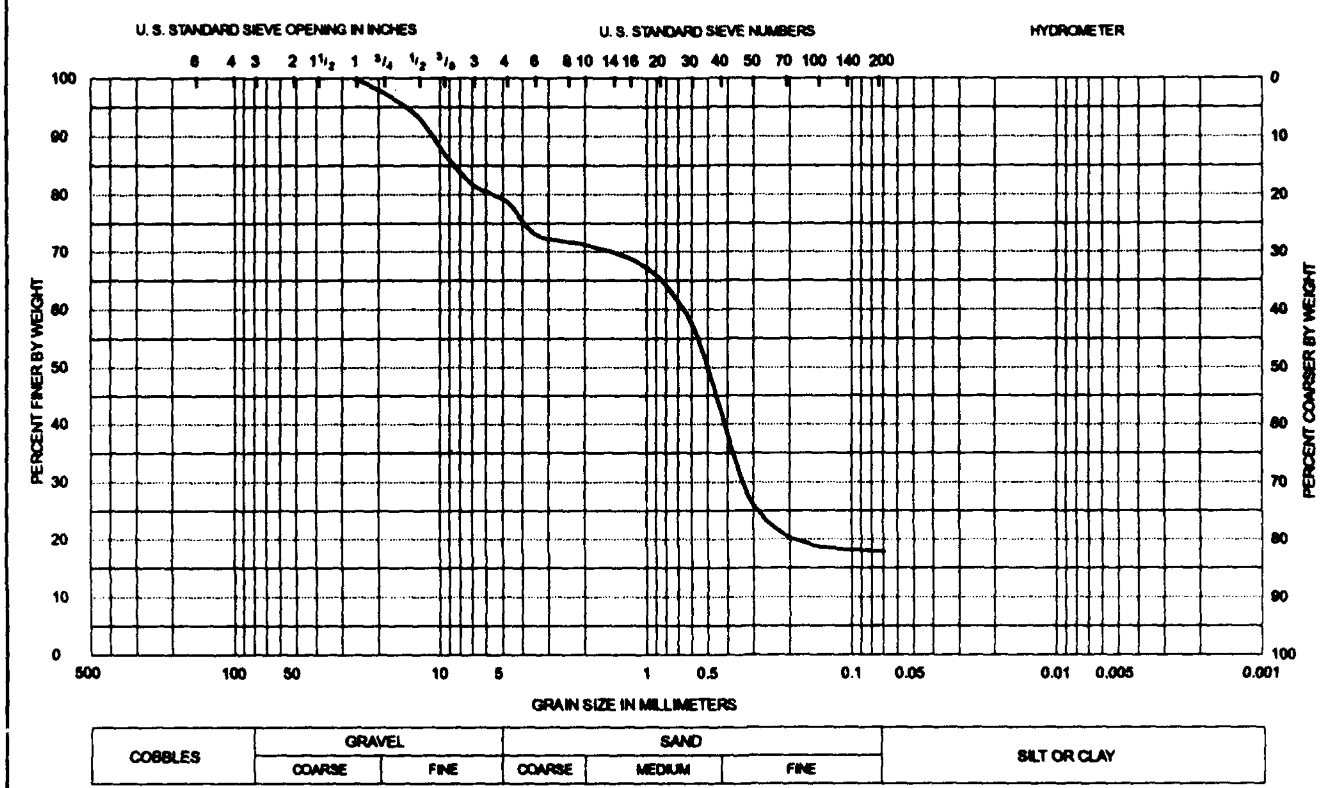
DATE 14 JUL 92

Figure 4. Gradation curve, silt (ML), brown



SAMPLE NO.	MATERIAL	CLASSIFICATION	NAT W%	LL	PL	PI		
		CLAYEY SILT (ML) BROWN		31	24	7	PROJECT	DUST CONTROL
							SOURCE	LEAN CLAY
							BORING NO.	
GRADATION CURVES							DATE	14 JUL 92

Figure 5. Gradation curve, clayey silt (ML), brown



SAMPLE NO.	MATERIAL	CLASSIFICATION	NAT W%	LL	PL	PI
		GRAVELLY CLAYEY SAND (SC), BROWN		24	11	13

PROJECT	DUST CONTROL
SOURCE	RED CLAY
BORING NO.	
DATE	14 JUL 92

GRADATION CURVES

Figure 6. Gradation curve, gravelly clayey sand (SC), brown

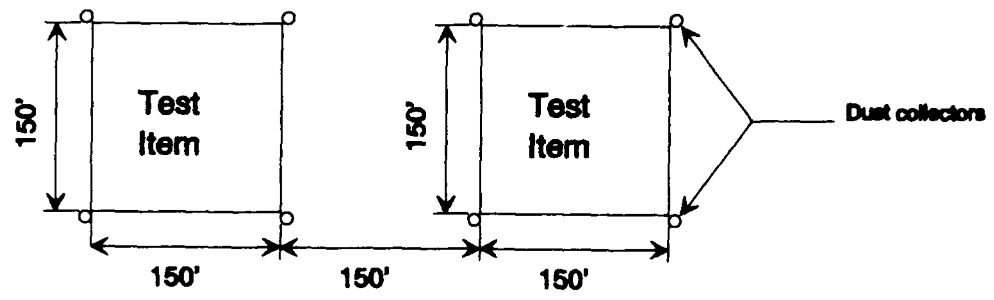


Figure 7. Typical helipad test sections

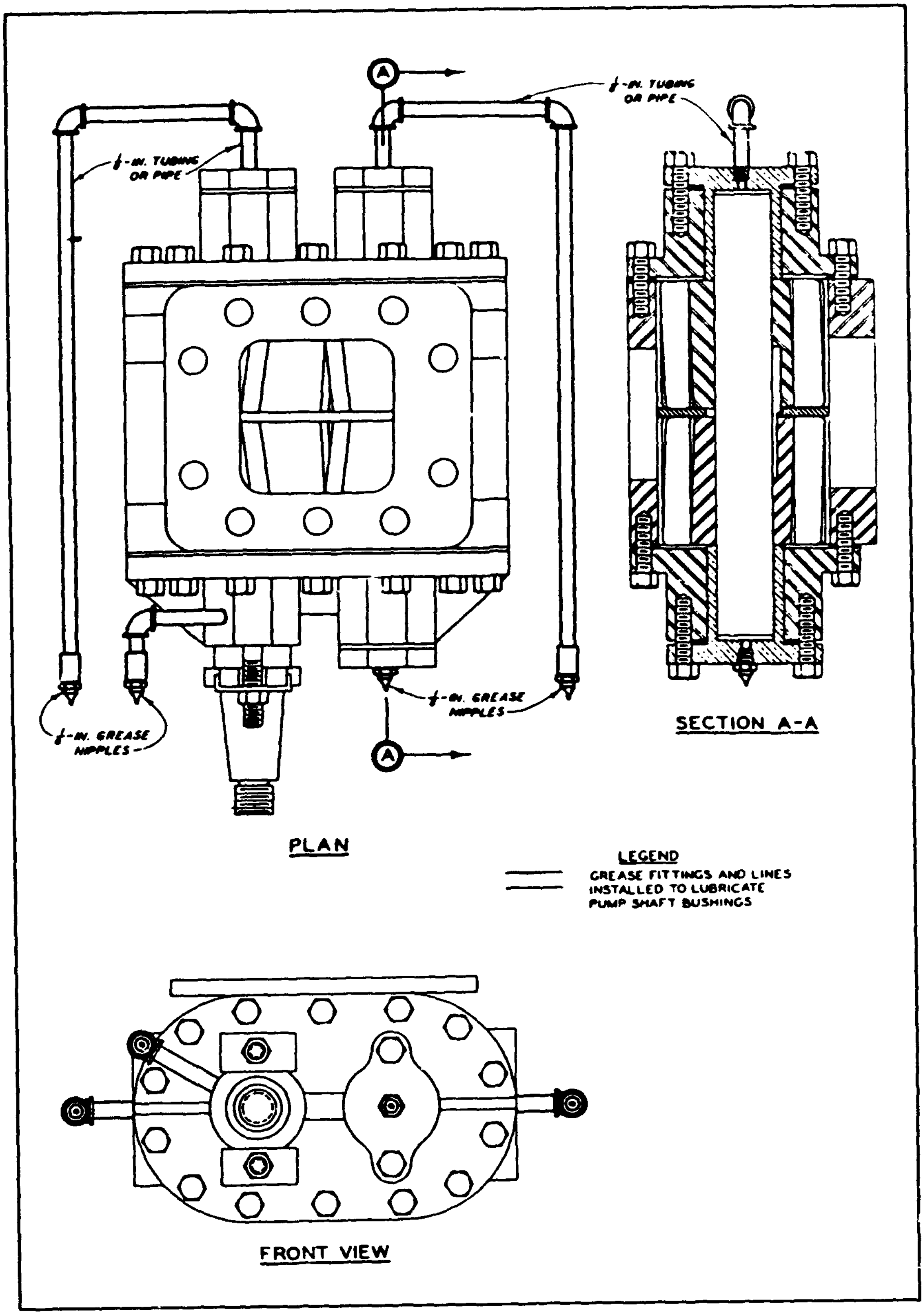


Figure 8. Typical pump modification requirements for conventional asphalt distributor

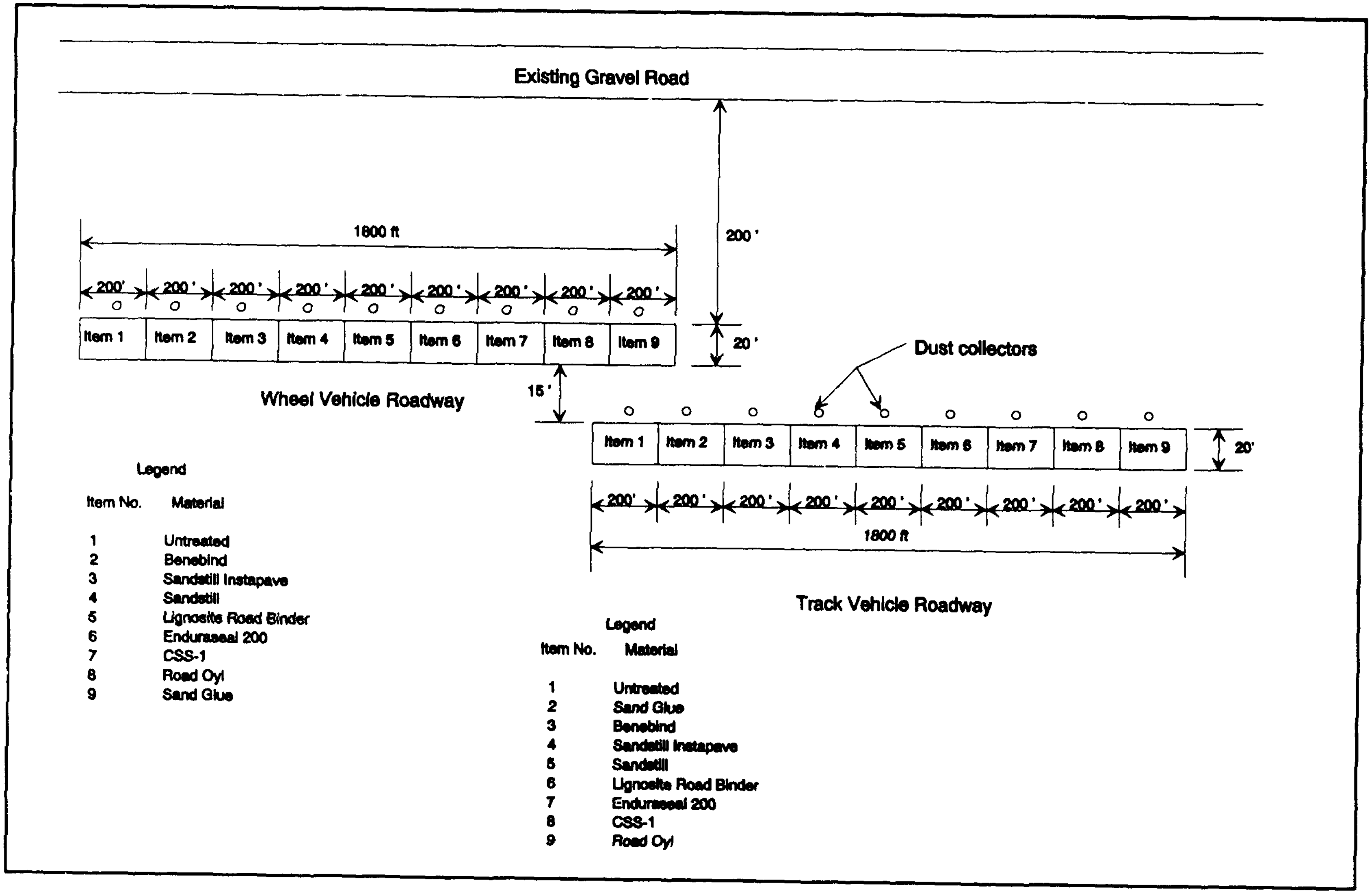


Figure 9. Wheel and track vehicle roadway test sections

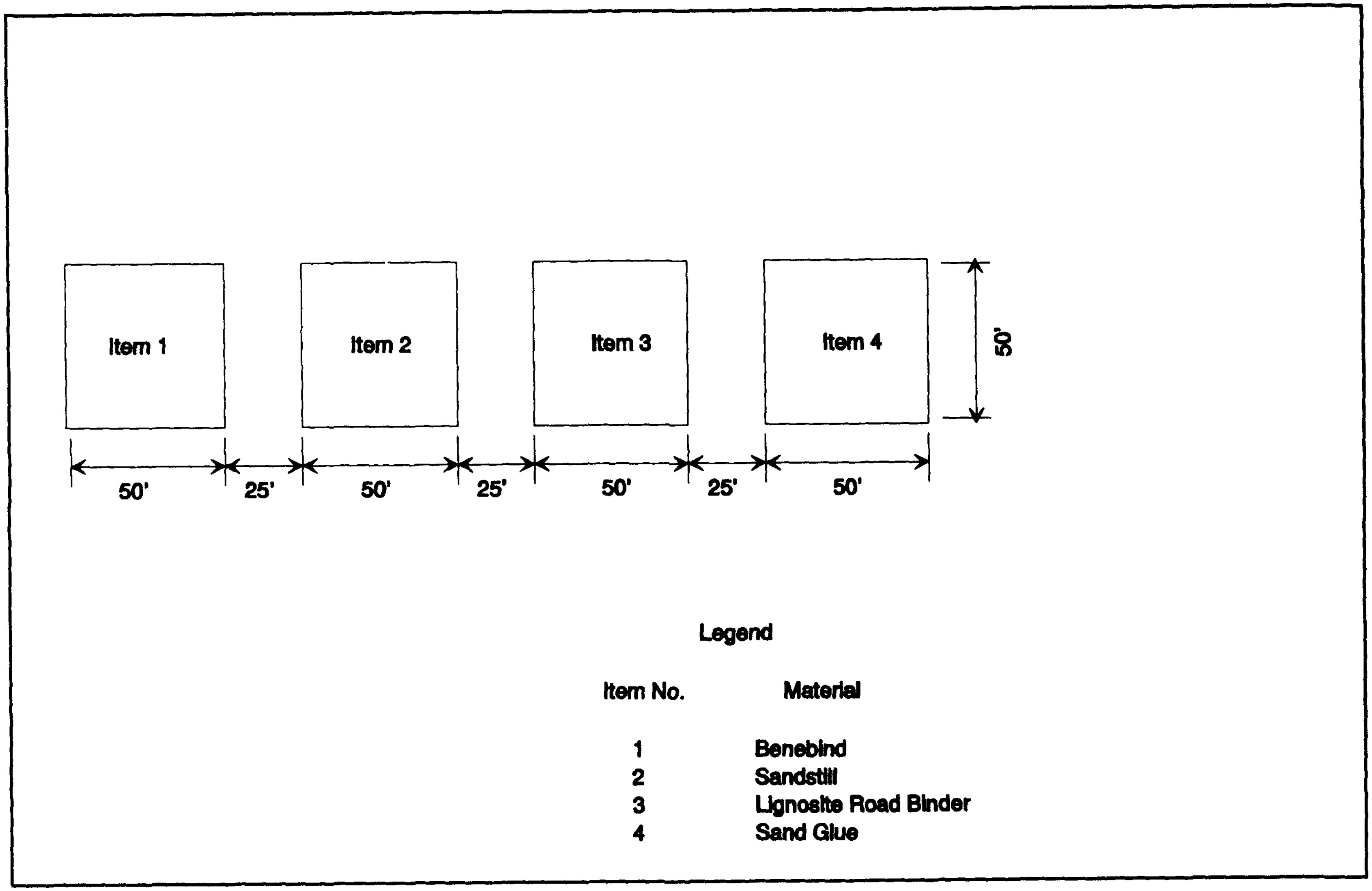


Figure 10. Nontrafficked test section

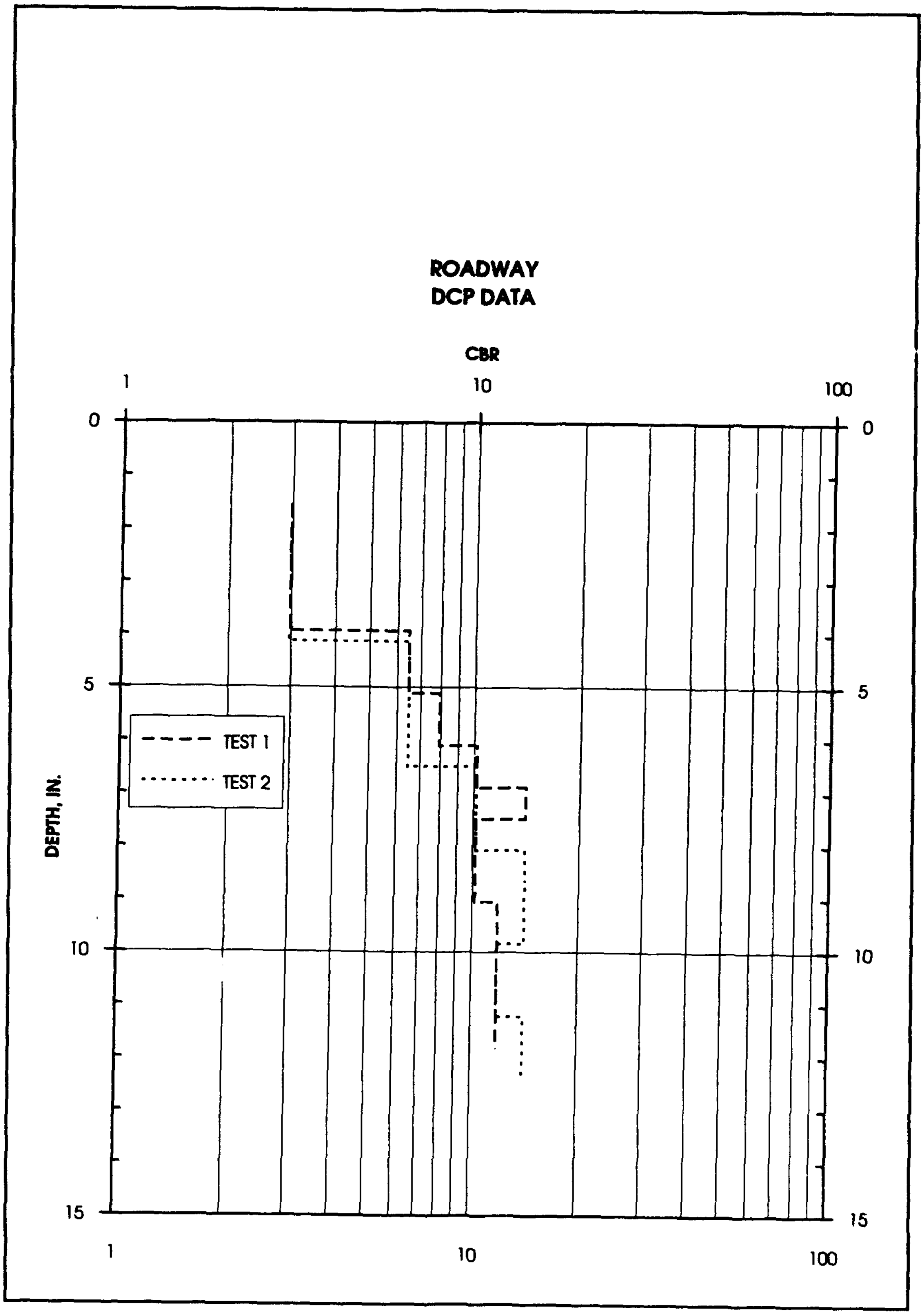


Figure 11. Dynamic cone penetrometer determinations

Photo 1. Compacted soil samples prior to treatment

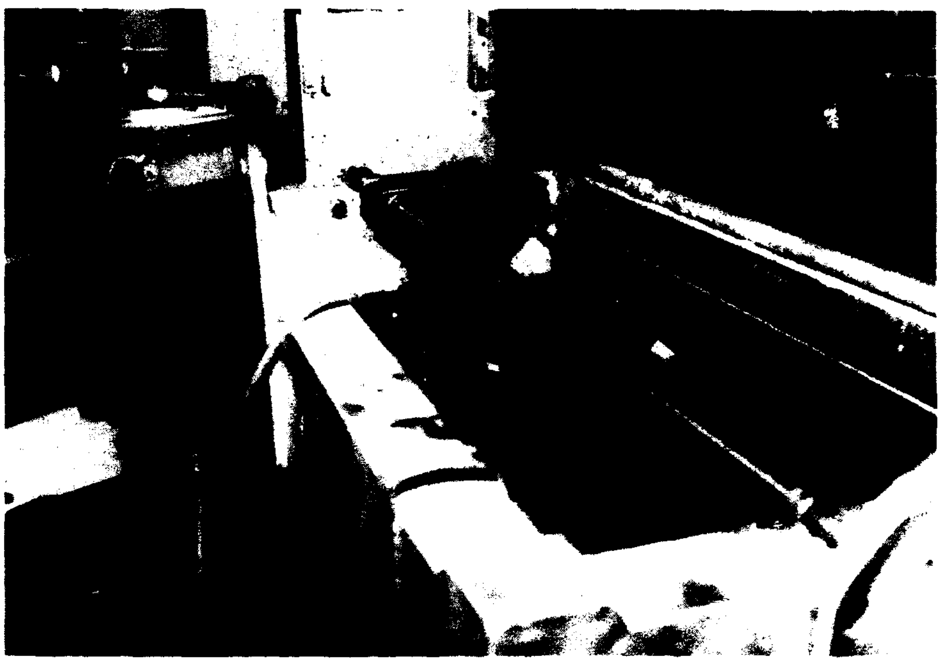


Photo 2. Laboratory application equipment

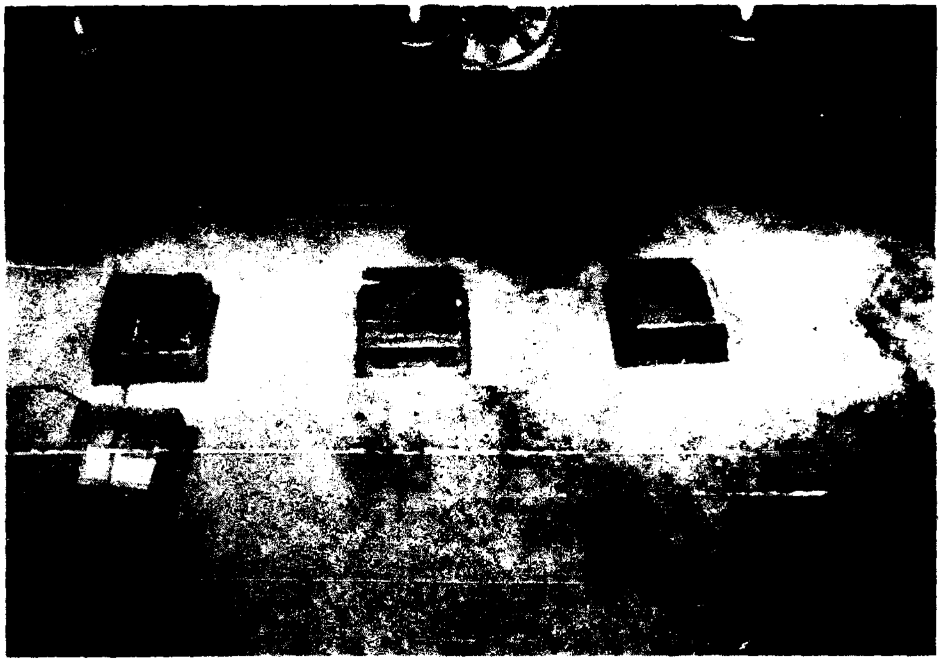


Photo 3. Treated soil samples curing under sun lamps

Photo 4. Test apparatus used to simulate air blast

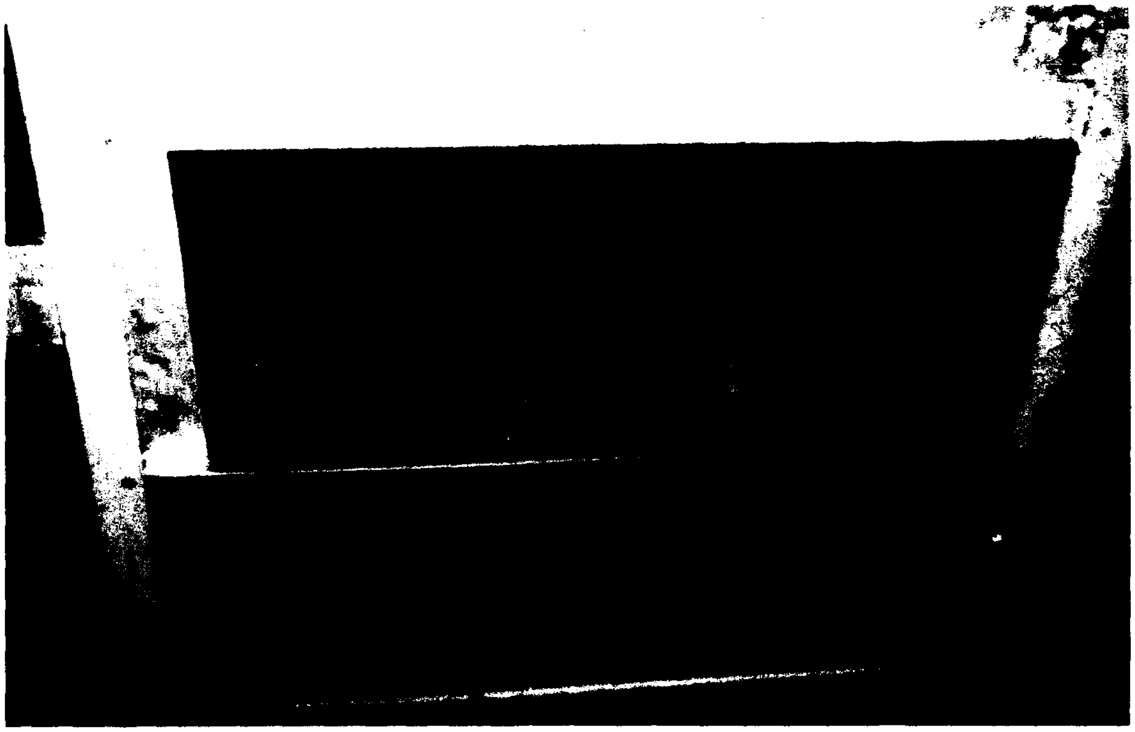


Photo 5. Test apparatus used to simulate rainfall

Photo 6. Helipad prior to treatment

Photo 7. Prewetting area prior to treatment

Photo 8. Application of product with asphalt distributor

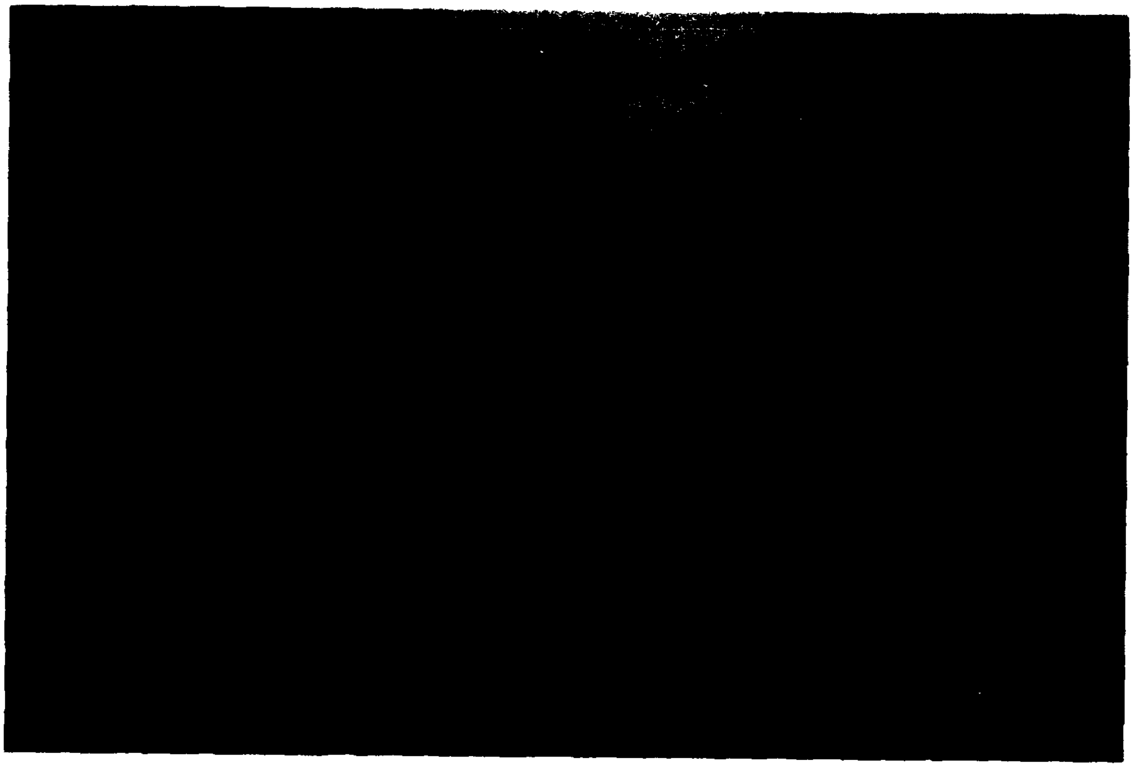


Photo 9. Roadway test section prior to treatment

Photo 10. Application of product to roadway test item

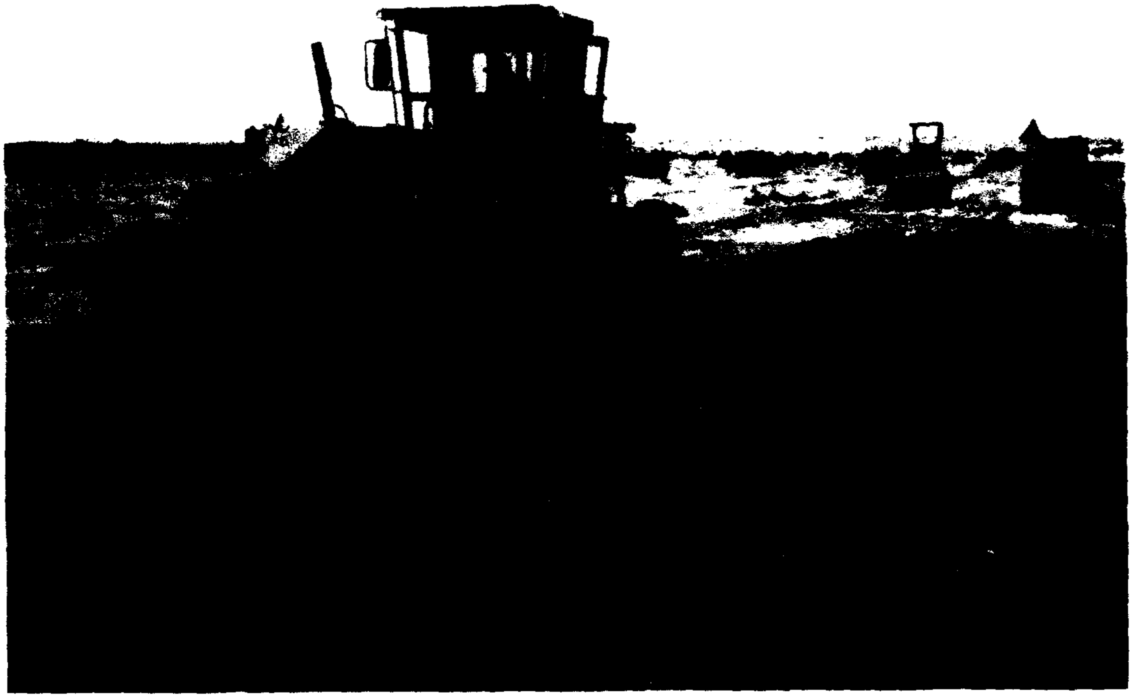


Photo 11. Admixing product with motor grader

Photo 12. Compacting treated item after admixing completed

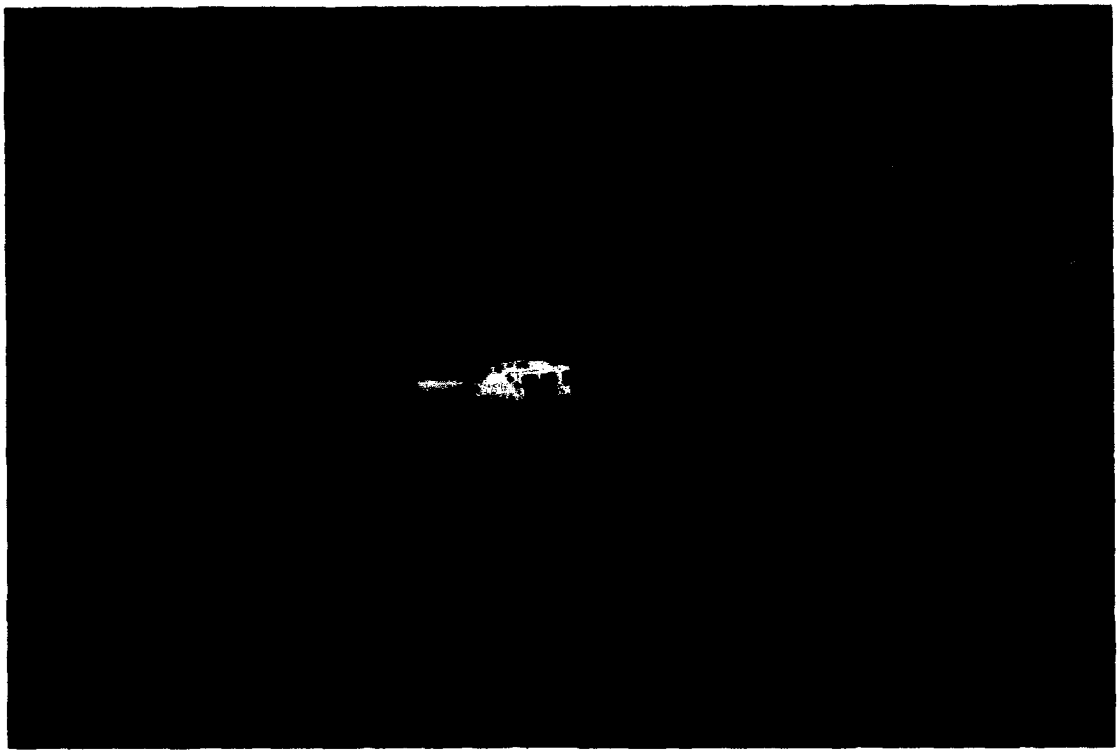


Photo 13. UH-1 Huey helicopter

Photo 14. M927 5-ton truck

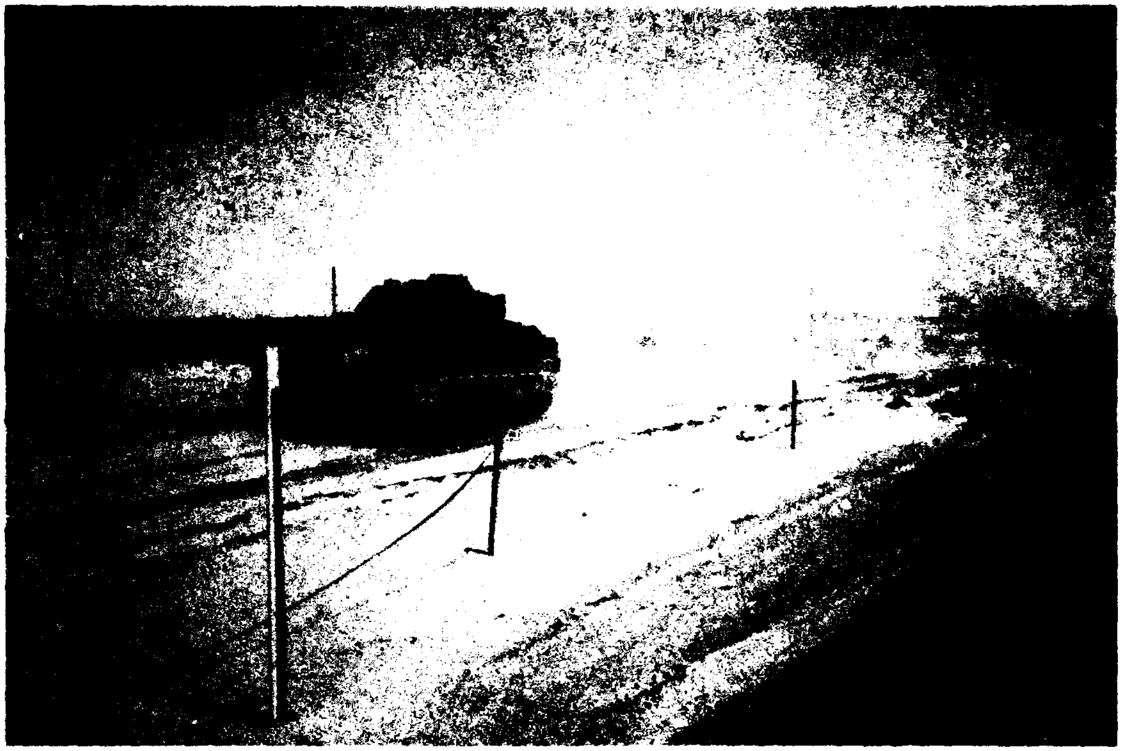


Photo 15. M2 Bradlev Infantry Fighting Vehicle

Photo 16. Painted board used to determine height of dust cloud

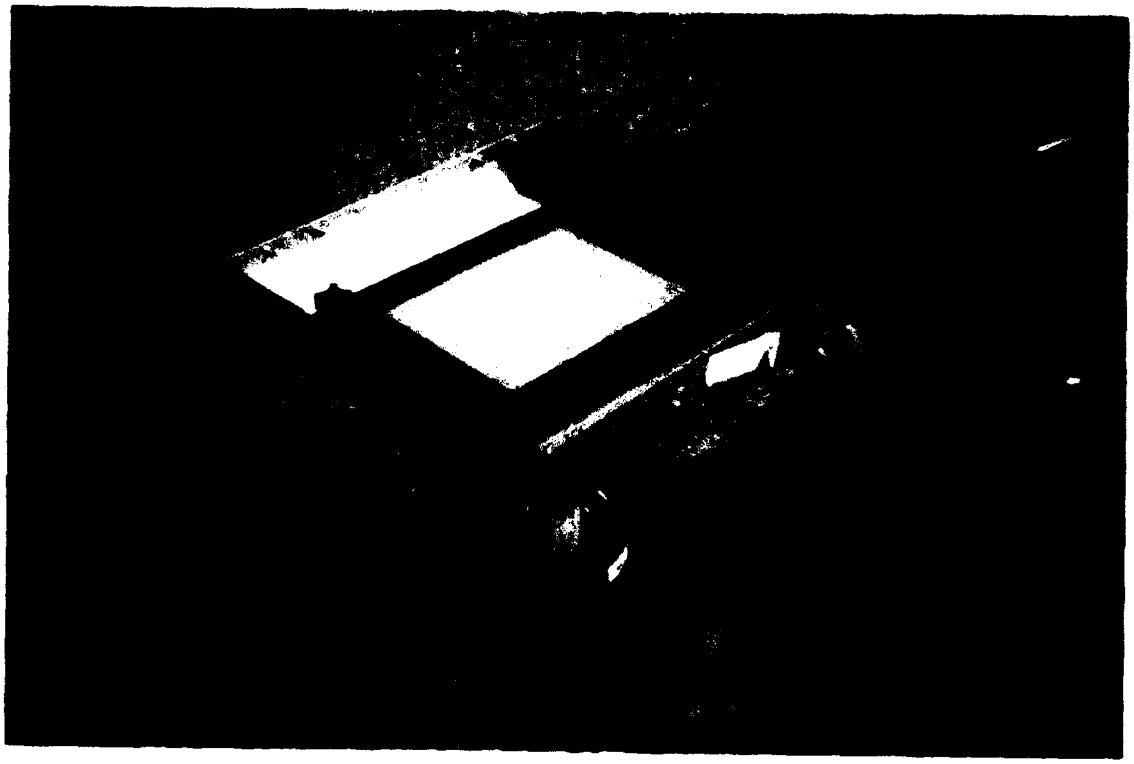


Photo 17. Filter mounted on dust collector

Photo 18. UH-1 helicopter hovering above treated helipad

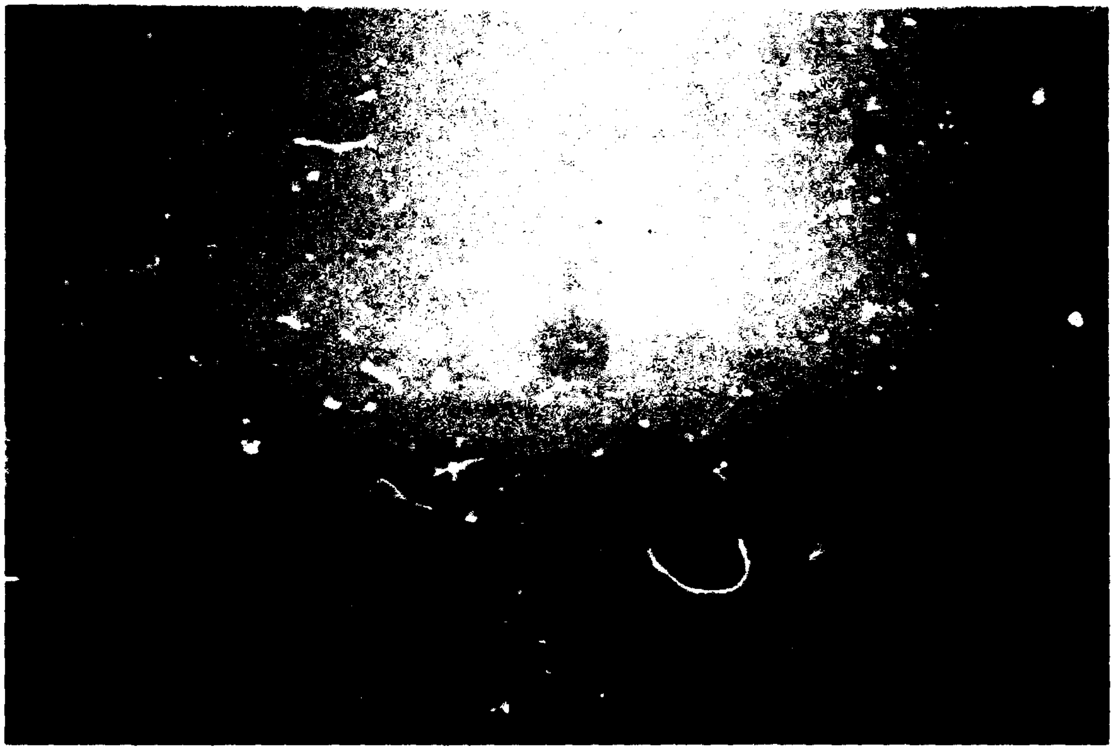


Photo 19. UH-1 helicopter hovering above nontreated helipad

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13. ABSTRACT *(Maximum 200 words)*

This report presents results of tests conducted to evaluate dust control products applied to helipads and wheel and tracked vehicle roadways. Approximately 30 products were evaluated in the laboratory, seven of these were selected for further evaluation when applied to field test sections located at Yuma Proving Ground, AZ.

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